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Webb

(10) **Patent No.: US 9,149,294 B2**
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(54) **HYBRID CANNULA AND METHODS FOR MANUFACTURING THE SAME**

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(51) **Int. Cl.**

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A61B 17/34	(2006.01)
A61M 39/06	(2006.01)
A61B 17/00	(2006.01)
A61M 39/02	(2006.01)

(52) **U.S. Cl.**

CPC ***A61B 17/3462*** (2013.01); ***A61B 17/3417*** (2013.01); ***A61B 17/3421*** (2013.01); *A61B 2017/00526* (2013.01); *A61B 2017/00964* (2013.01); *A61B 2017/349* (2013.01); *A61B 2017/3441* (2013.01); *A61M 39/0247* (2013.01); *A61M 2039/027* (2013.01); *A61M 2039/0261* (2013.01); *A61M 2039/0279* (2013.01); *A61M 2039/0686* (2013.01); *Y10T 29/49826* (2015.01); *Y10T 29/49908* (2015.01)

(58) **Field of Classification Search**

CPC A61B 17/3498; A61B 2017/3441; A61M 2039/0633; A61M 2039/0686; A61M 39/06; A61M 2039/0646; A61M 2039/064; A61M 2039/066

USPC 604/167.01–167.04

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,320,611	A	6/1994	Bonutti et al.
5,573,517	A	11/1996	Bonutti et al.
5,601,590	A	2/1997	Bonutti et al.
5,667,500	A	9/1997	Palmer et al.
5,674,240	A	10/1997	Bonutti et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP	1908428	A1	4/2008
EP	1908428	B1	1/2011

(Continued)

OTHER PUBLICATIONS

WECK Vista Teleflex™ brochure, 2012, 6 pages.

(Continued)

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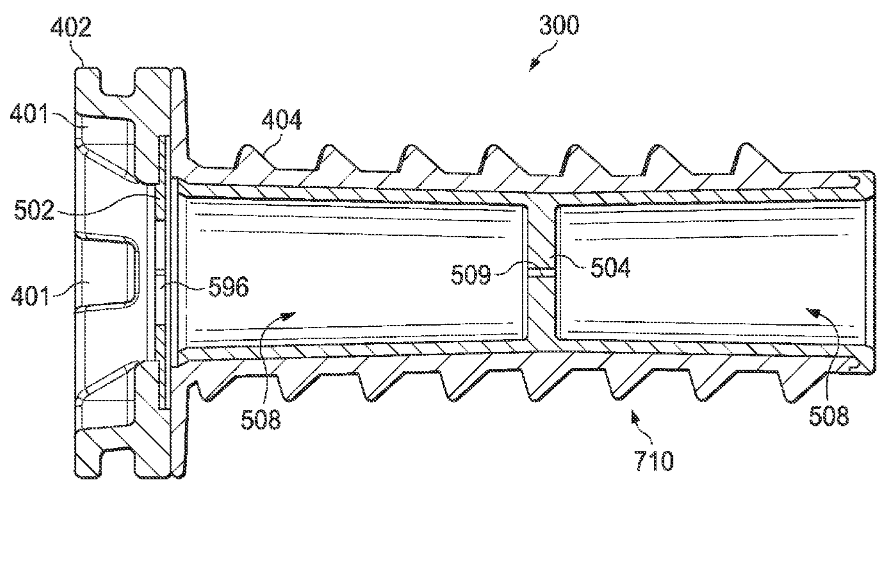
(57) **ABSTRACT**

A hybrid cannula may comprise a first portion formed from a first material, a second portion formed from a second material overmolded to the first portion, a third portion formed from a third material and a fourth portion formed from a fourth material overmolded to the third material. The third portion is coupled to the first portion. The first portion may prevent the proximal end of the hybrid cannula from being pushed through a portal. The second portion may include a membrane and the fourth portion may include a dam, the dam defining interior spaces thereof between the proximal and distal ends of the hybrid cannula. The membrane and/or dam may prevent liquid from projecting during insertion or removal of instruments. The distal end of the hybrid cannula may comprise a variety of features.

18 Claims, 18 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

5,779,697	A	7/1998	Glowa et al.	
5,800,409	A	9/1998	Bruce	
5,824,002	A	10/1998	Gentelia et al.	
5,961,499	A	10/1999	Bonutti et al.	
6,338,730	B1	1/2002	Bonutti et al.	
6,451,041	B1	9/2002	Moenning et al.	
6,613,038	B2	9/2003	Bonutti et al.	
6,808,492	B2	10/2004	Snyder	
6,814,715	B2	11/2004	Bonutti et al.	
7,413,542	B2	8/2008	Kucklick et al.	
7,435,214	B2	10/2008	Kucklick et al.	
7,445,596	B2	11/2008	Kucklick et al.	
7,473,243	B2	1/2009	Dennis et al.	
7,503,893	B2	3/2009	Kucklick	
7,520,489	B2	4/2009	Ruschke et al.	
7,575,565	B2	8/2009	Kucklick	
7,896,897	B2	3/2011	Gresham et al.	
7,993,299	B2	8/2011	Kucklick	
7,998,061	B2	8/2011	Kucklick	
8,012,083	B2	9/2011	Kucklick	
8,025,648	B2	9/2011	Kucklick	
8,038,652	B2	10/2011	Morrison et al.	
8,092,431	B2	1/2012	Lunn et al.	
8,118,731	B2	2/2012	Kucklick	
8,123,676	B2	2/2012	Kucklick	
2005/0059934	A1 *	3/2005	Wenchell et al.	604/167.01
2007/0088277	A1	4/2007	McGinley et al.	
2007/0106319	A1	5/2007	Au et al.	
2007/0255218	A1 *	11/2007	Franer	604/167.02
2008/0294123	A1	11/2008	Lunn et al.	
2009/0030375	A1 *	1/2009	Franer et al.	604/167.01
2009/0221968	A1	9/2009	Morrison et al.	
2010/0094227	A1	4/2010	Albrecht et al.	
2010/0268241	A1	10/2010	Flom et al.	
2012/0089160	A1	4/2012	Lunn et al.	
2012/0089161	A1	4/2012	Lunn et al.	
2012/0245426	A1	9/2012	Salvas et al.	
2012/0323081	A1	12/2012	Son	
2013/0317472	A1	11/2013	Finke	
2014/0206942	A1	7/2014	Webb	
2014/0207084	A1	7/2014	Webb	

FOREIGN PATENT DOCUMENTS

KR	101090665	B1	12/2011
WO	WO2012/044959		4/2012

OTHER PUBLICATIONS

Dry-Doc Cannula Leak Prevention System product sheet and web site product information, ConMed Linvatec, Largo, FL, Sep. 2008, CBR 3035 Rev. 1, 3 pgs.

AquaLoc Cannula System product brochure, Biomet Sports Medicine, Warsaw IN, 2008, 3 pgs. BSM0141.0, REV022908.

Managing fluid and sutures without compromise, Clear-Trac Complete Cannula System product brochure, Smith & Nephew, Inc., Andover, MA, Oct. 2007, 5 pgs., 1061531 Rev. C.

Portion of Arthrex product brochure entitled "The Next Generation in Shoulder Repair Technology," Arthrex Inc., 2008, 7 pages.

Cannuflow, Arthroscopy without limits, Products Overview, Cannuflow, 2012, 3 pgs., at <<http://www.cannuflow.com/products.html>>.

Caps-Lock cannula product brochure, ArthroCare Sports Medicine, Sunnyvale, CA, 2007, 4 pgs, PN AT 50-2009 Rev C.

Dri-Lok Disposable Cannula product sheet, Stryker Corp., Kalamazoo, MI, 2012, 1 pg.

Clear Cannula System product information, The new fluid management solution for all your arthroscopic procedures, DePuy Mitek, Inc., Raynham, MA, 2008, 2 pgs.

International Search Report and Written Opinion issued for PCT Application No. PCT/US2013/068977, mailed Jan. 30, 2014, 10 pages.

International Search Report and Written Opinion issued for PCT Application No. PCT/US2013/068978, mailed Jan. 30, 2014, 8 pages.

Sportport™ Cannuflow product brochure, "The Easy to Use Super-Flexible Portal Cannula System that Surgeons Have Been Waiting for," Cannuflow Incorporated, 2013, 2 pages.

International Search Report and Written Opinion issued for PCT Application No. PCT/US2013/068975, mailed Feb. 20, 2014, 8 pages.

Office Action issued for U.S. Appl. No. 13/749,492, mailed Dec. 24, 2014, 8 pages.

Notice of Allowance issued for U.S. Appl. No. 13/749,492, mailed Apr. 24, 2015, 7 pages.

International Preliminary Report on Patentability (IPRP) issued for PCT Application No. PCT/US2013/068977, mailed Aug. 6, 2015, 9 pages.

Notice of Allowance issued fo U.S. Appl. No. 13/749,492, mailed Jul. 21, 2015, 7 pages.

International Preliminary Report on Patentability (IPRP) issued for PCT Application No. PCT/US2013/068975, mailed Aug. 6, 2015, 7 pages.

* cited by examiner

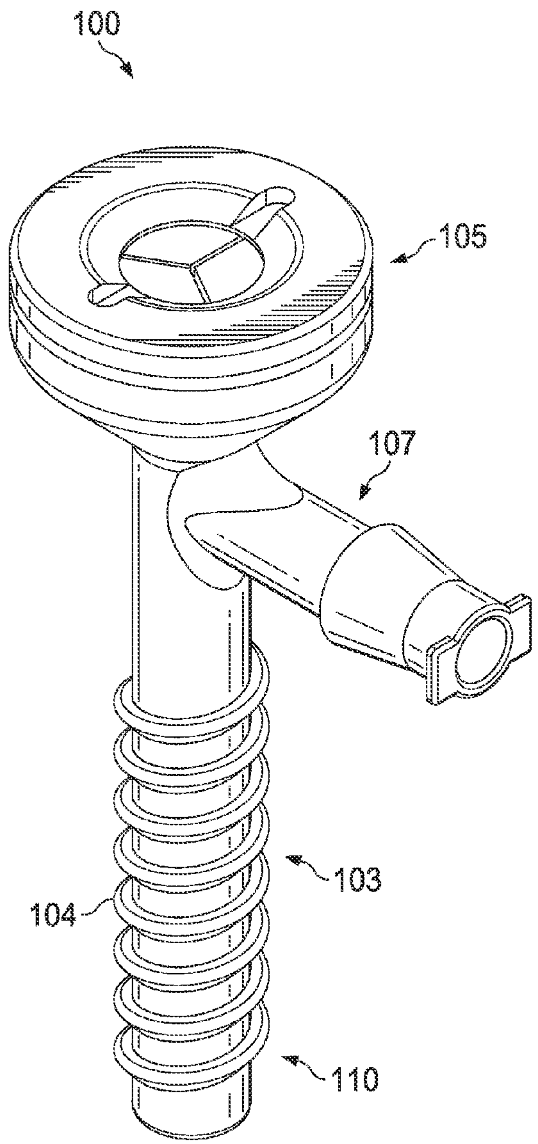


FIG. 1a
(PRIOR ART)

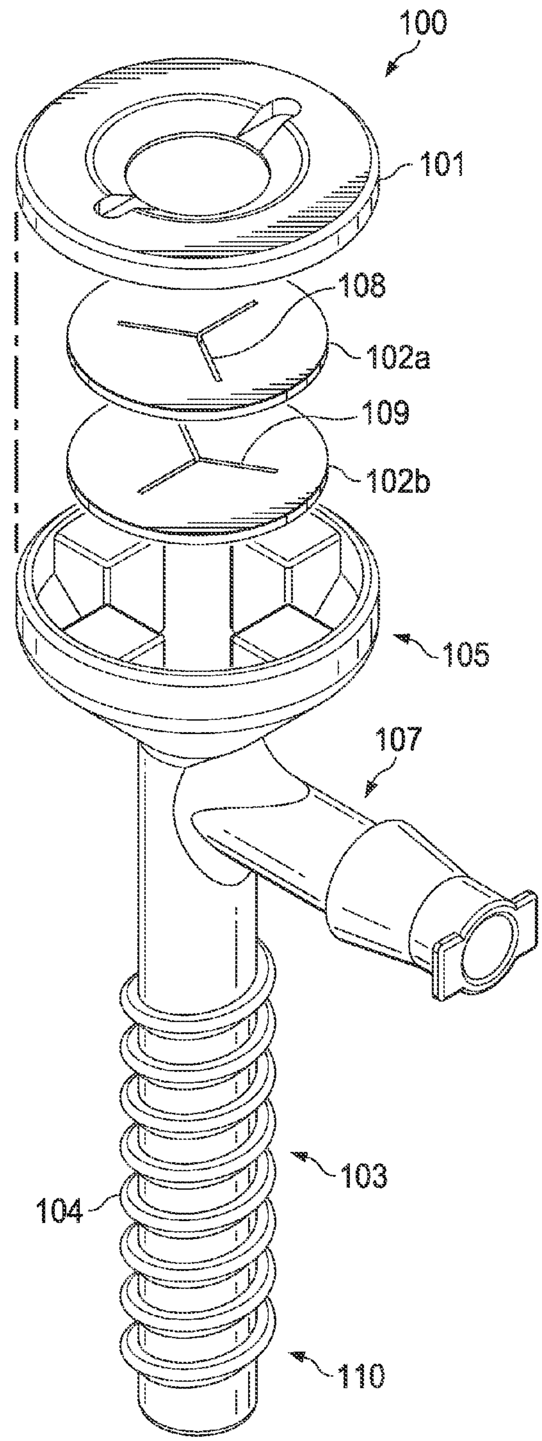


FIG. 1b
(PRIOR ART)

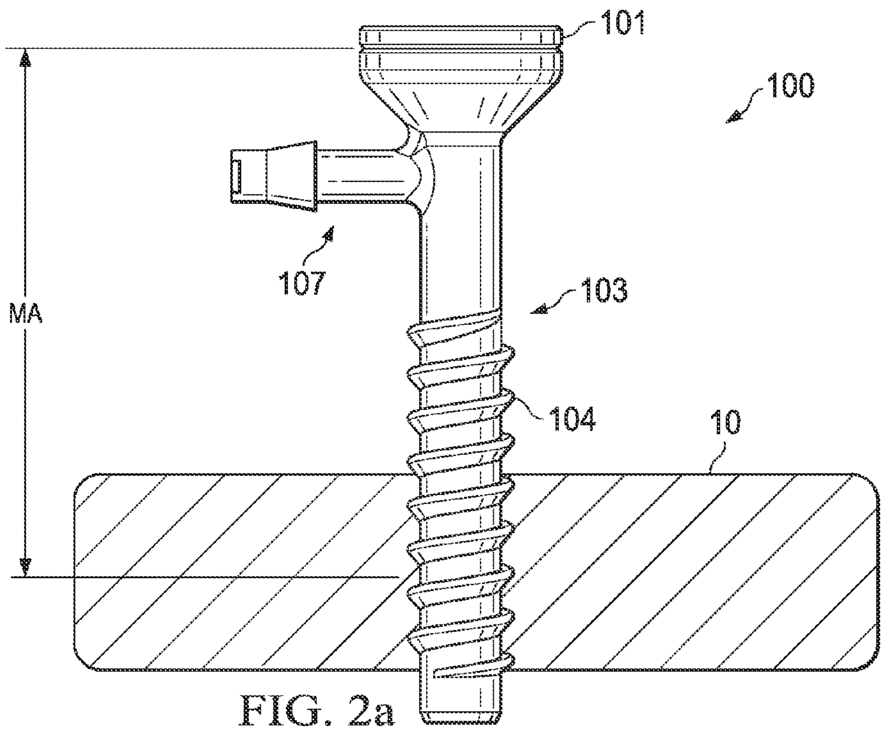


FIG. 2a
(PRIOR ART)

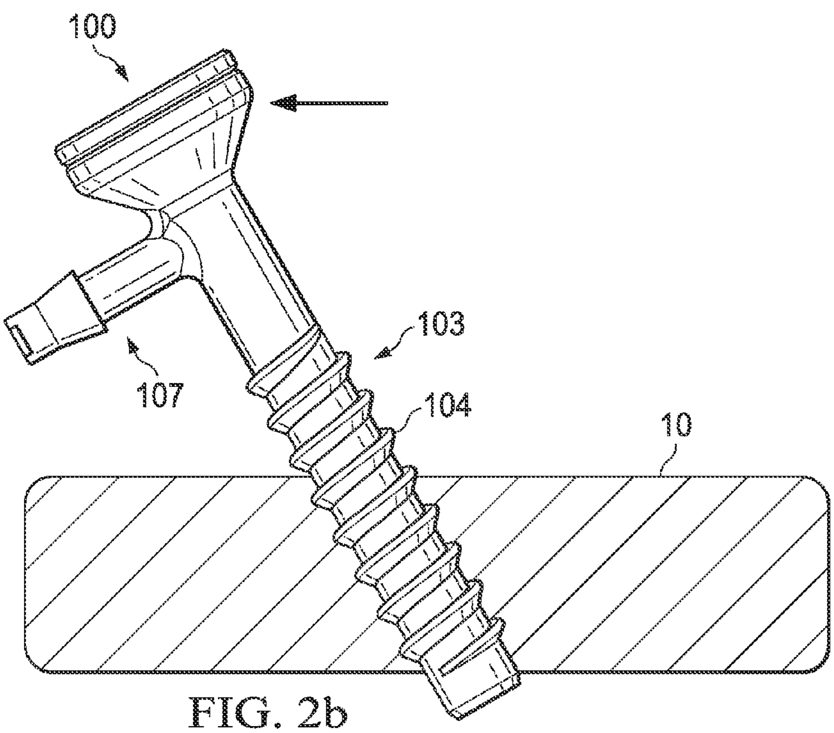


FIG. 2b
(PRIOR ART)

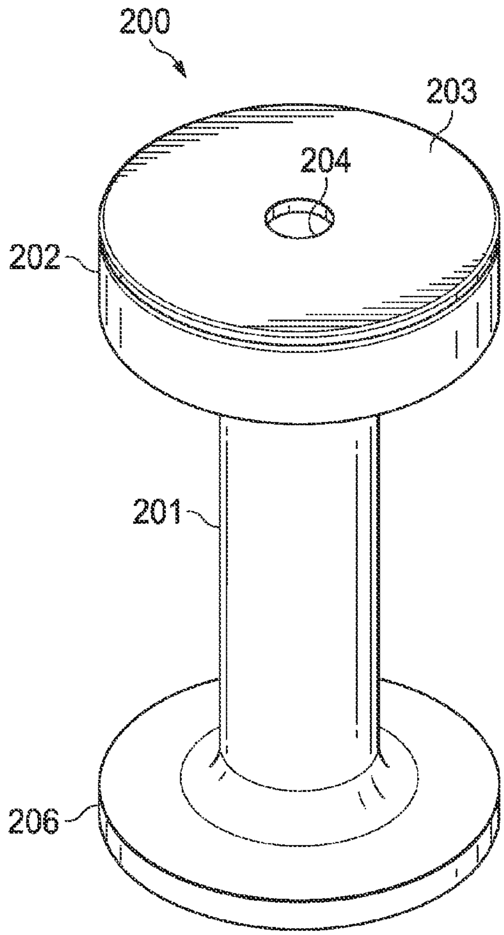


FIG. 3a
(PRIOR ART)

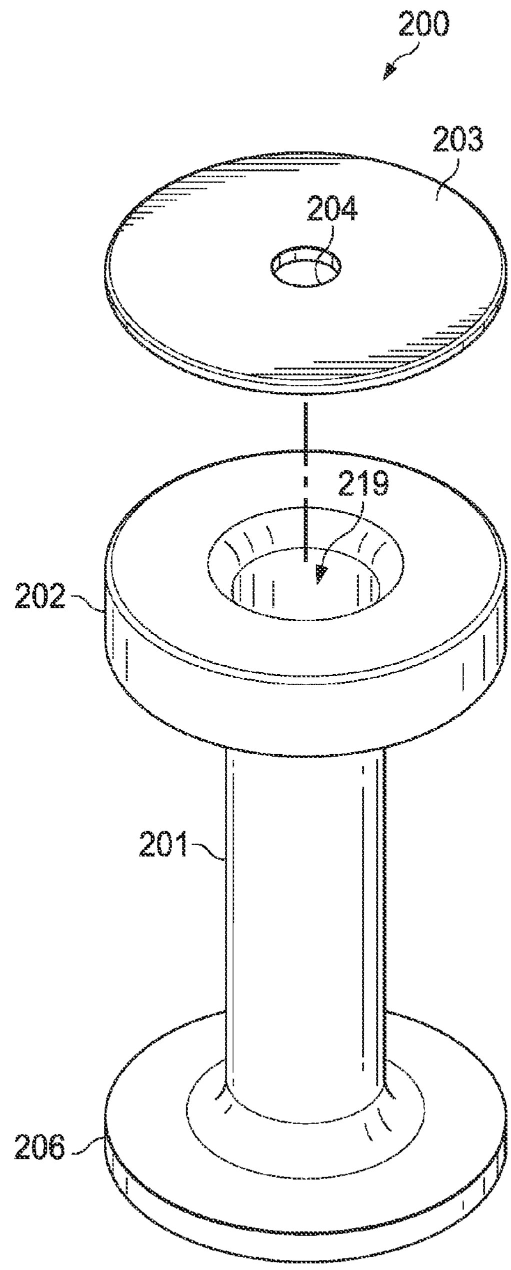


FIG. 3b
(PRIOR ART)

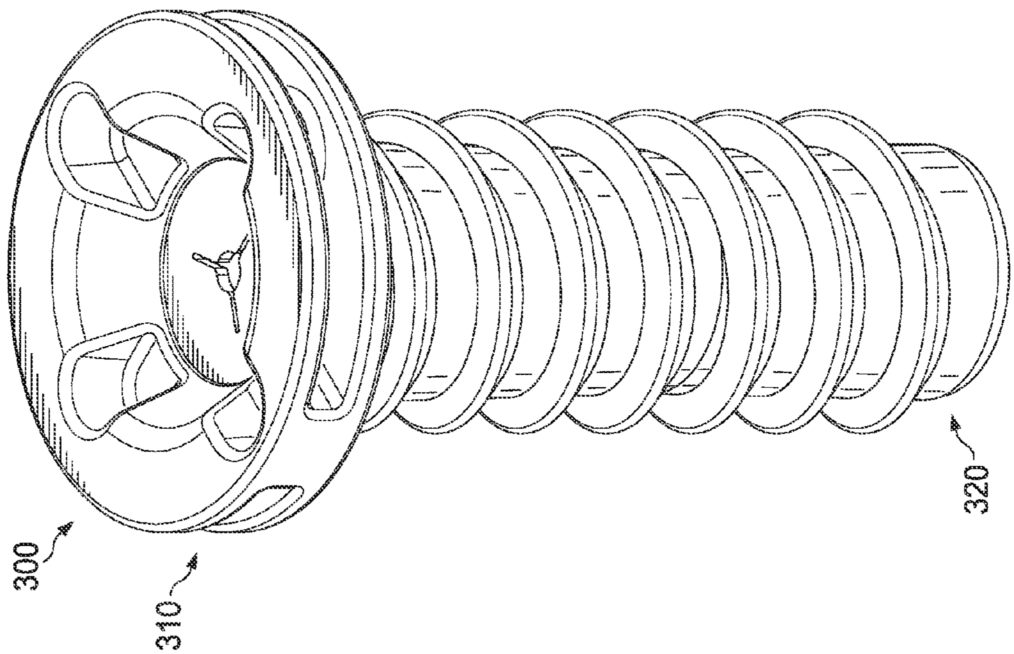


FIG. 5

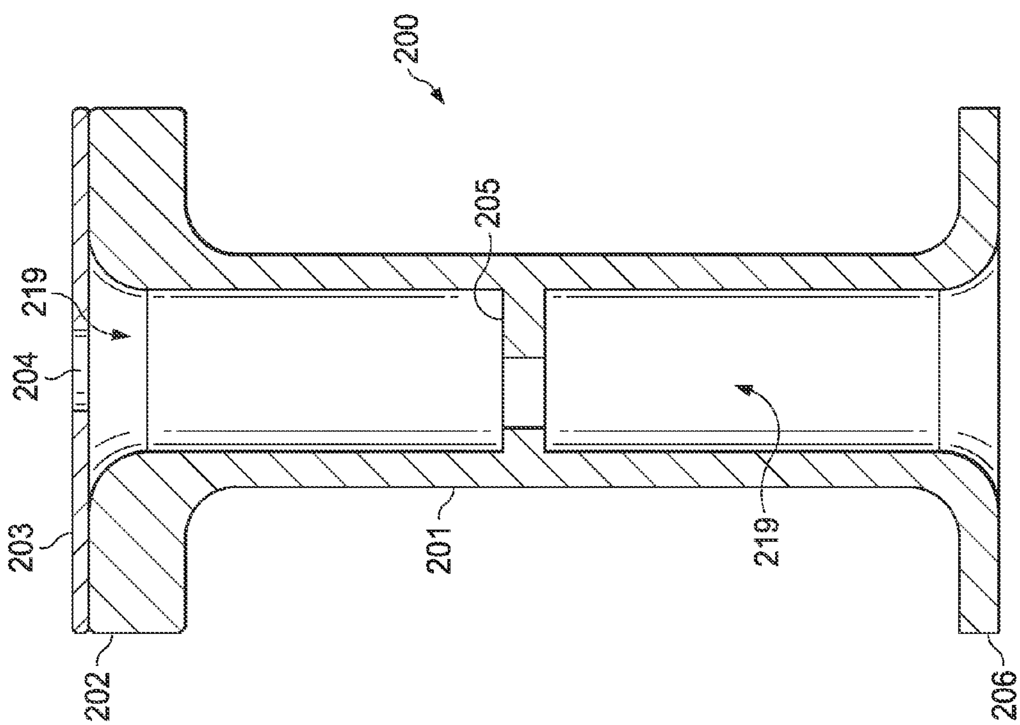


FIG. 4
(PRIOR ART)

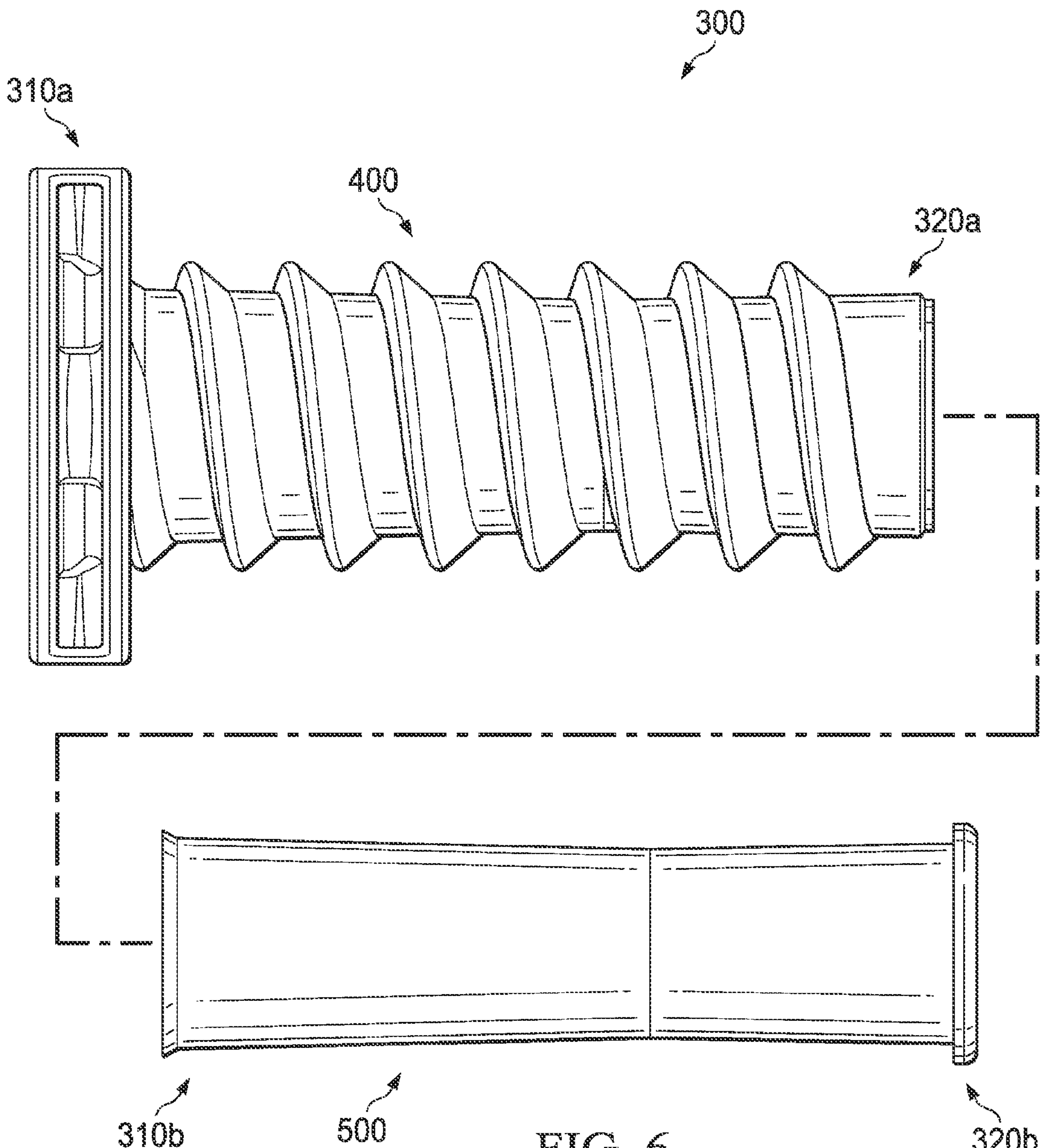


FIG. 6

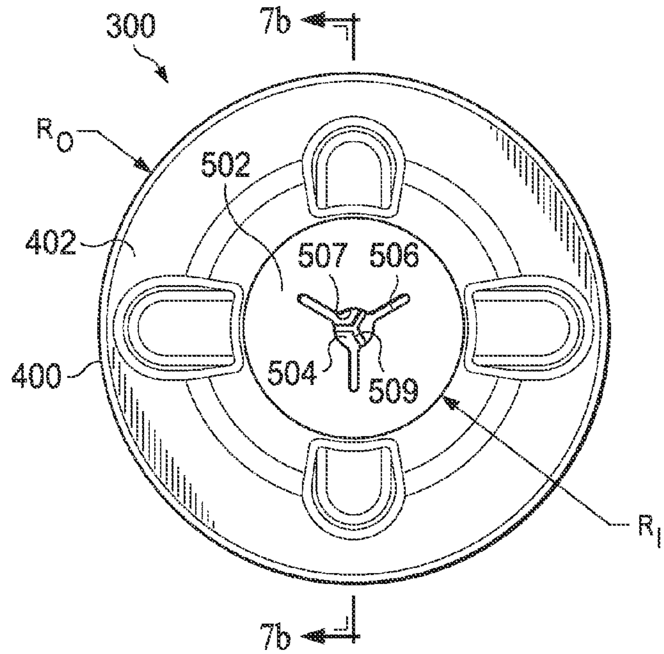
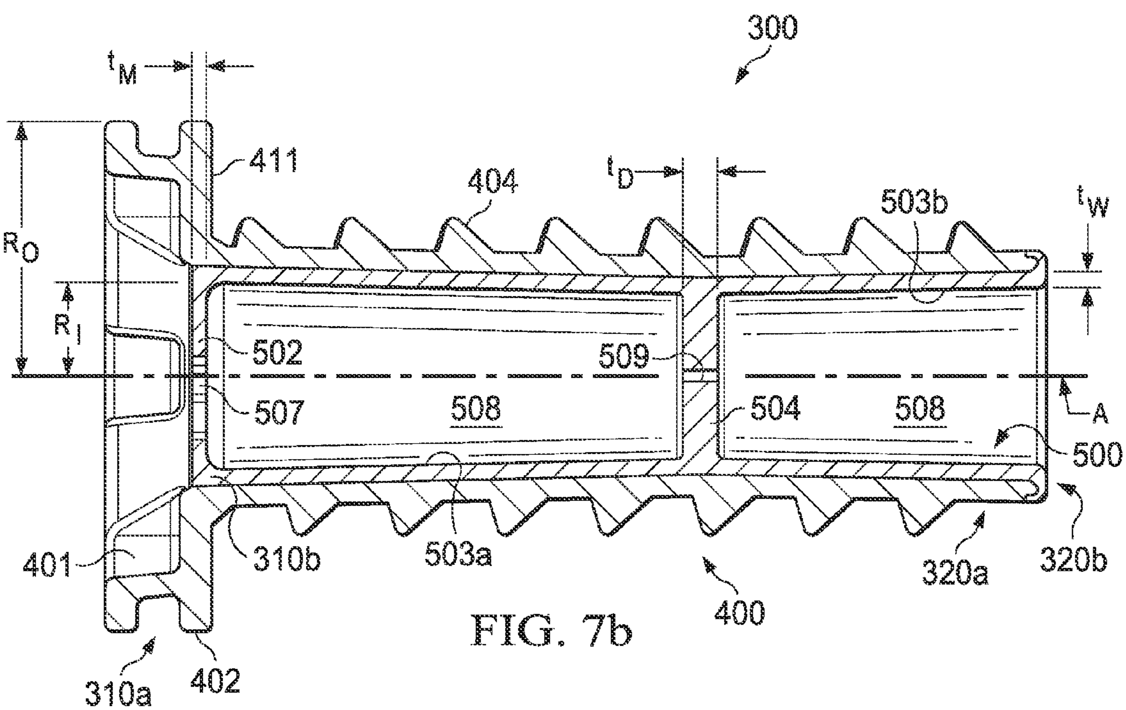

300
7b
R_O
502
402
507
506
400
504
509
R_I
7b

FIG. 7a


300
t_M
411
404
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503b
t_W
R_O
R_I
502
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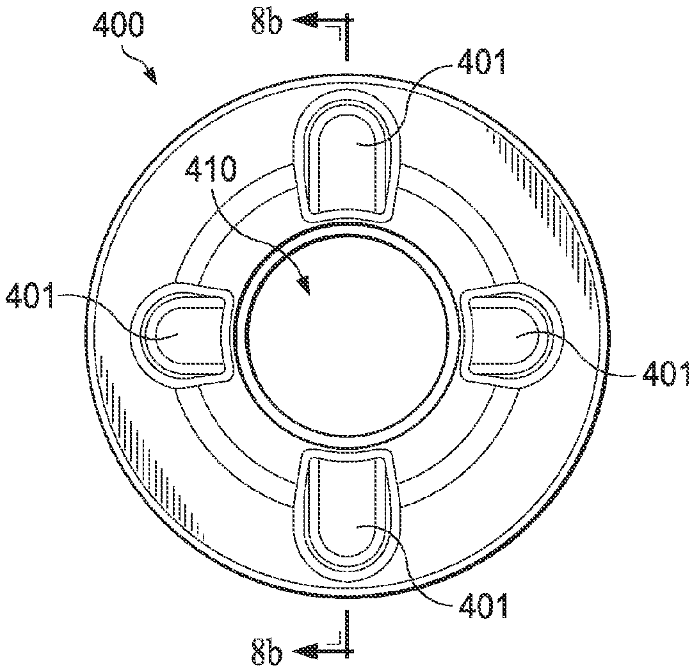
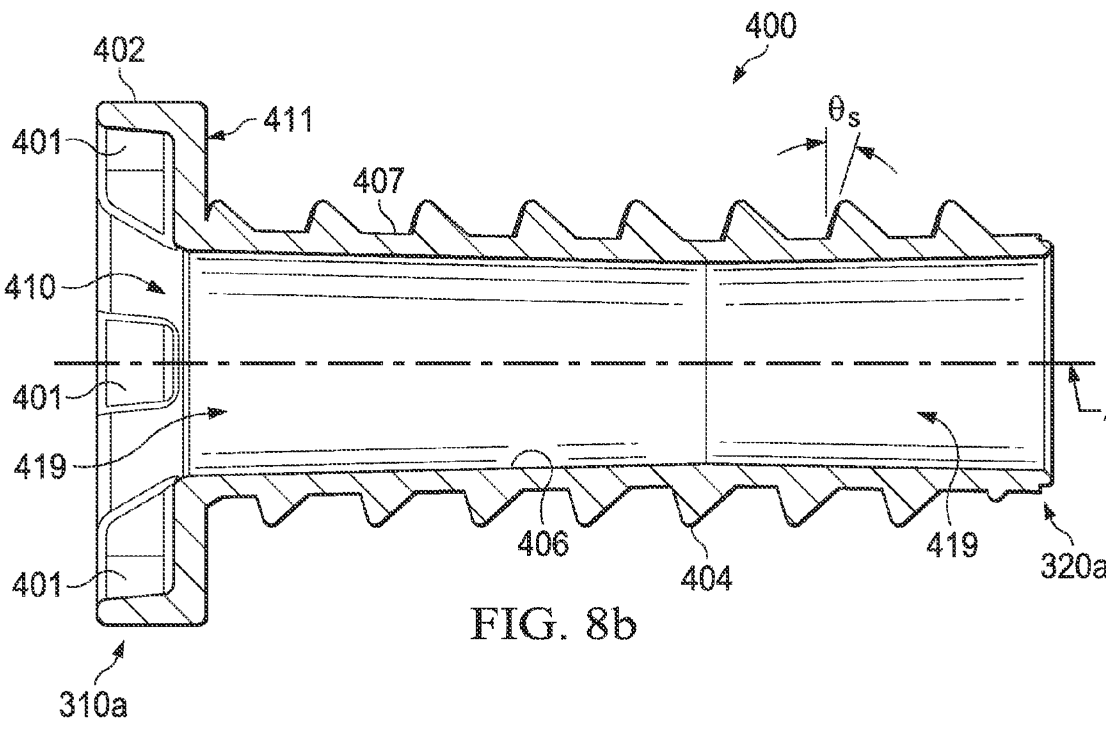
504
508
A
500
401
310b
503a
400
320a
320b
310a
402

FIG. 7b



400
8b
401
410
401
401
401
8b

FIG. 8a



402
400
401
411
θs
407
410
401
A
419
406
404
419
320a
401
310a

FIG. 8b

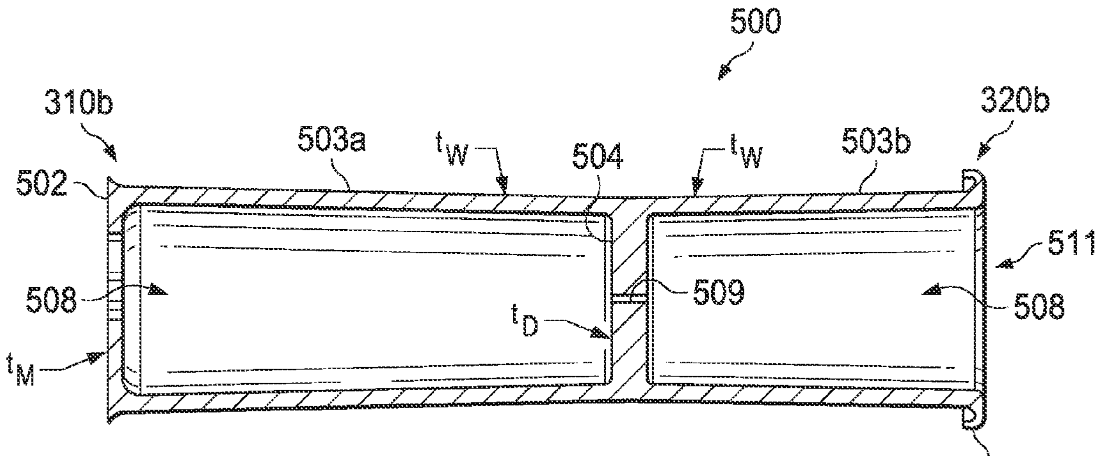


FIG. 9a

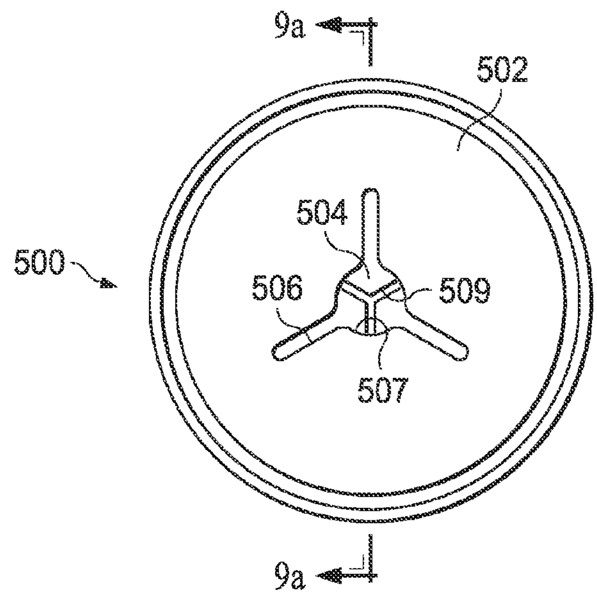


FIG. 9b

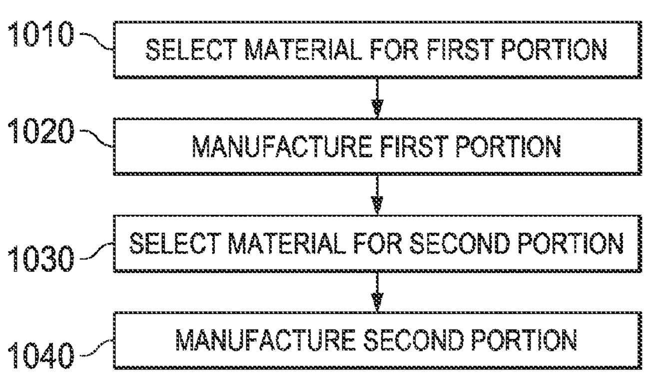
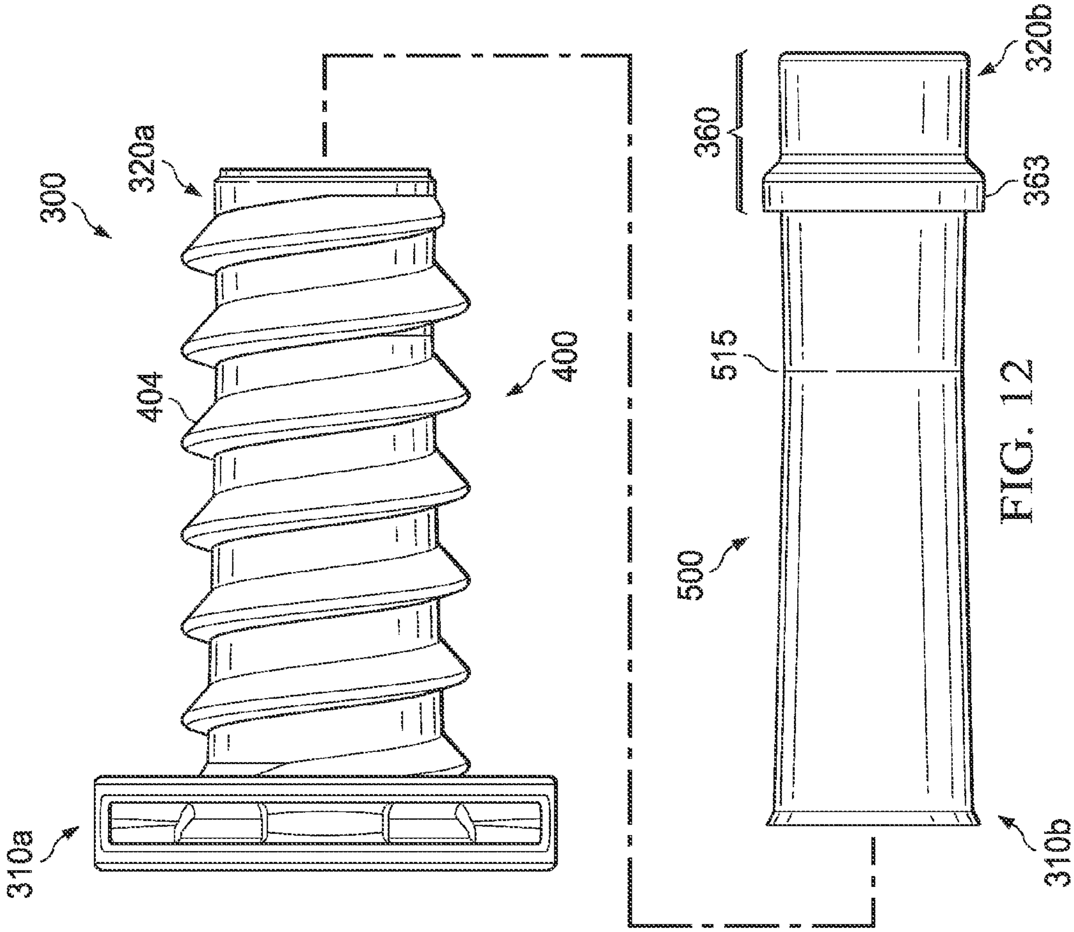


FIG. 10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320a
320b
360
363
404
400
515
500
310a
310b

FIG. 12

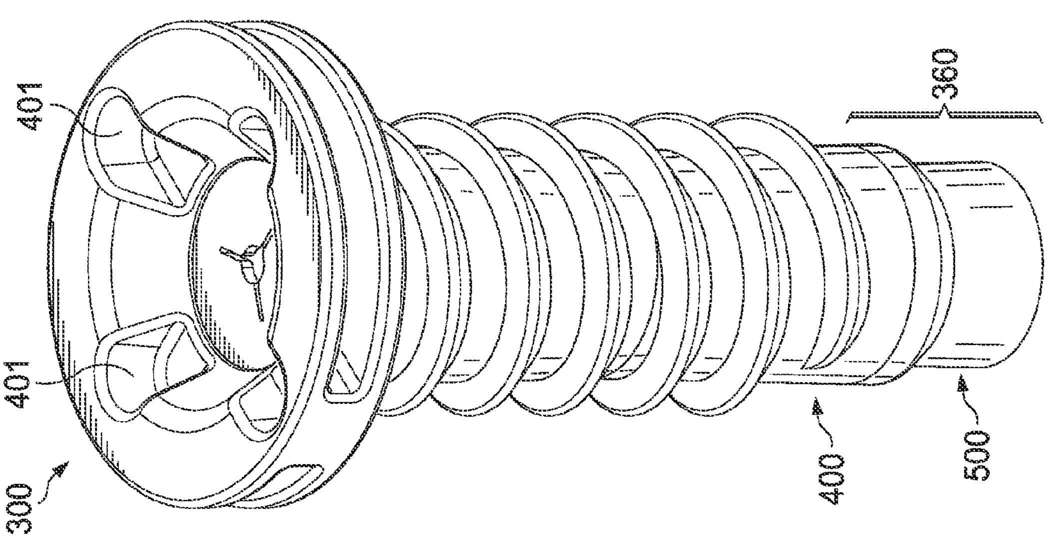
401
401
300
360
400
500

FIG. 11

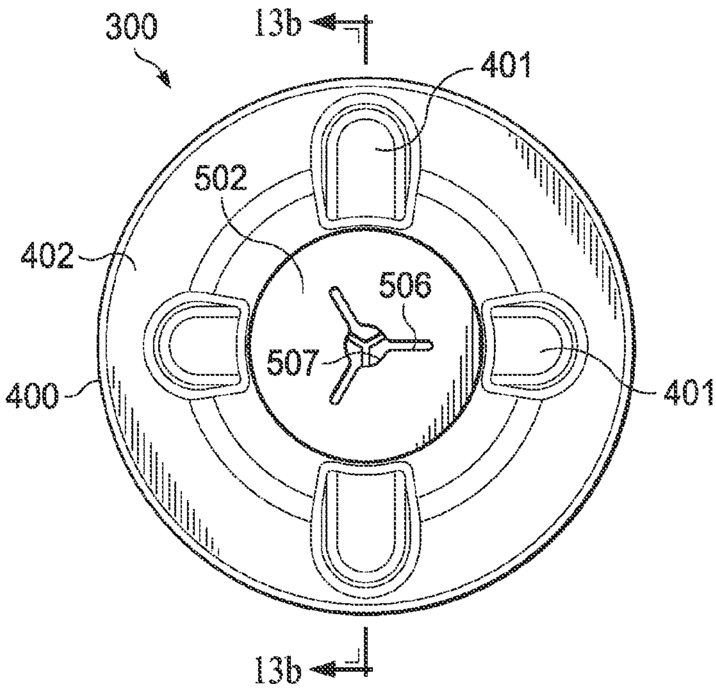

FIG. 13a

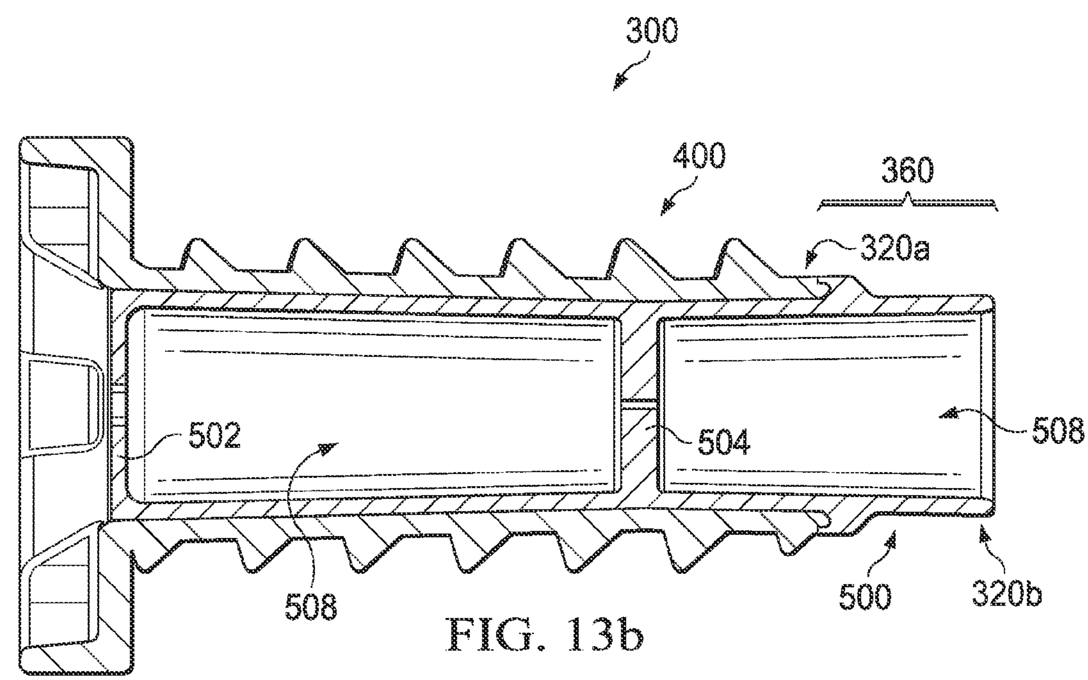

FIG. 13b

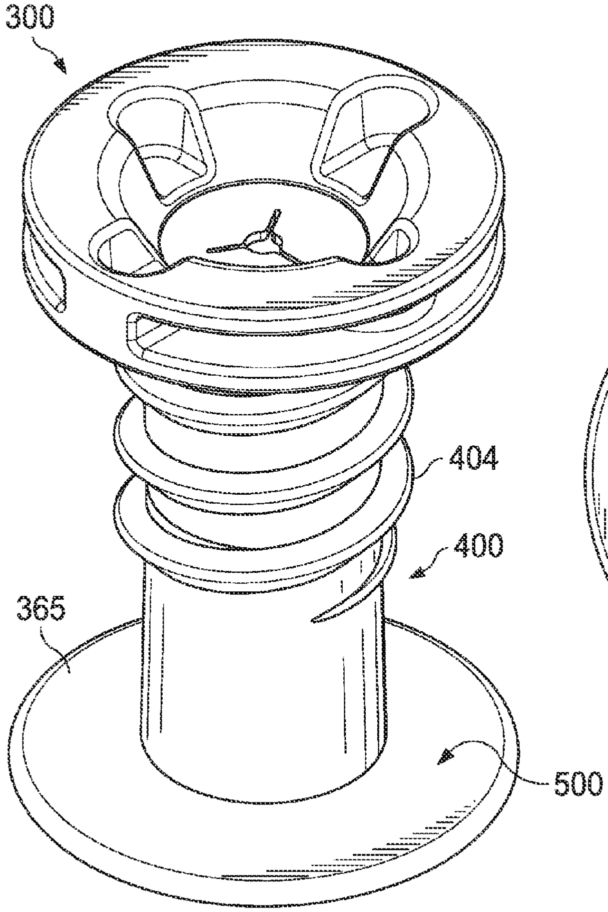

FIG. 14

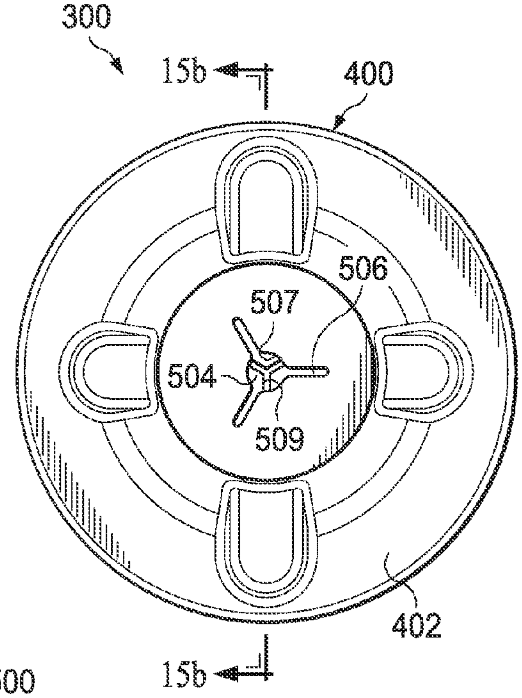

FIG. 15a

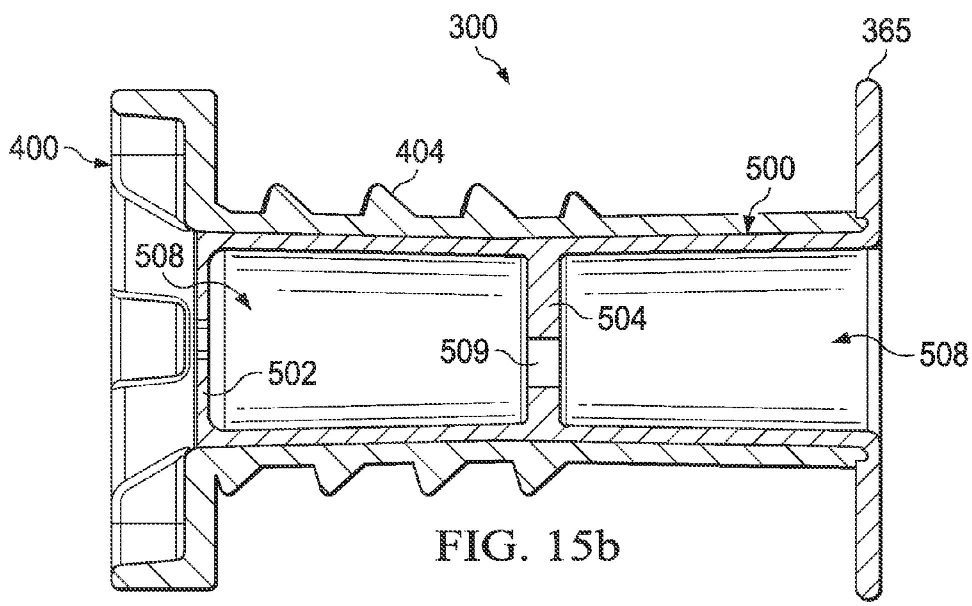

FIG. 15b

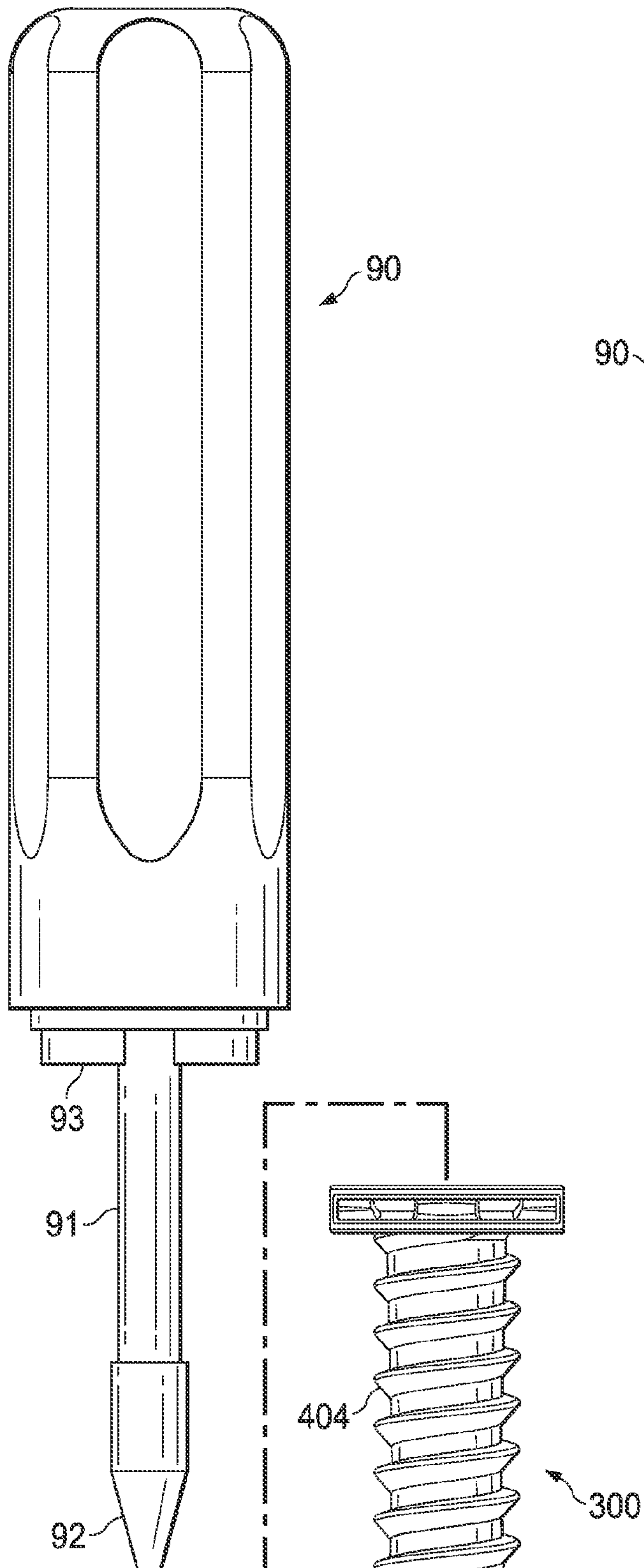

FIG. 16a

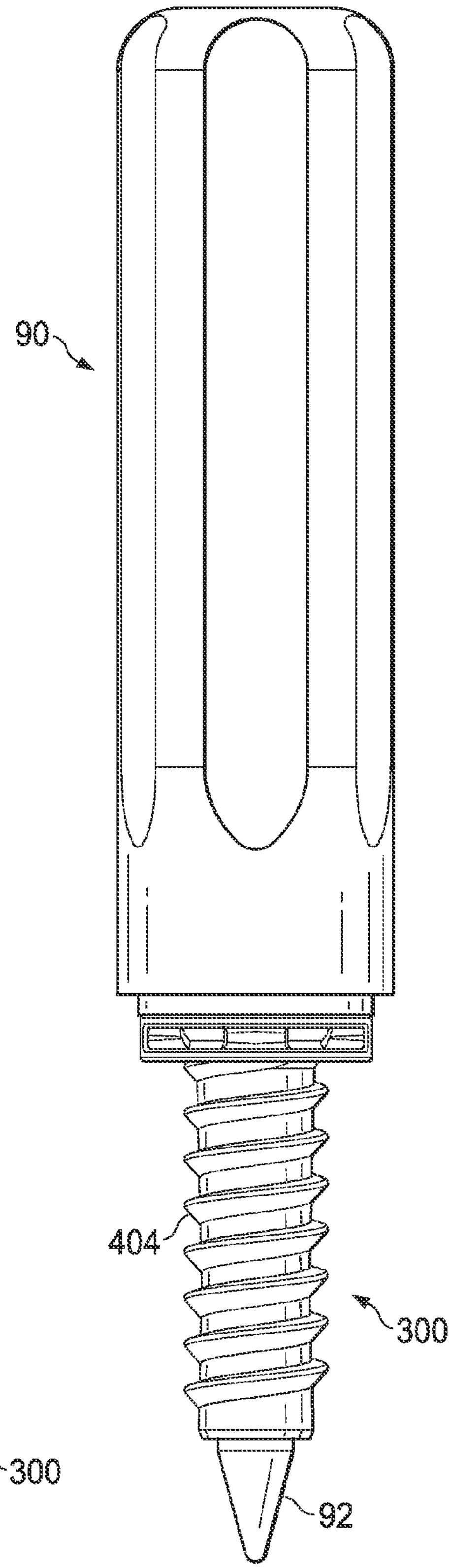

FIG. 16b

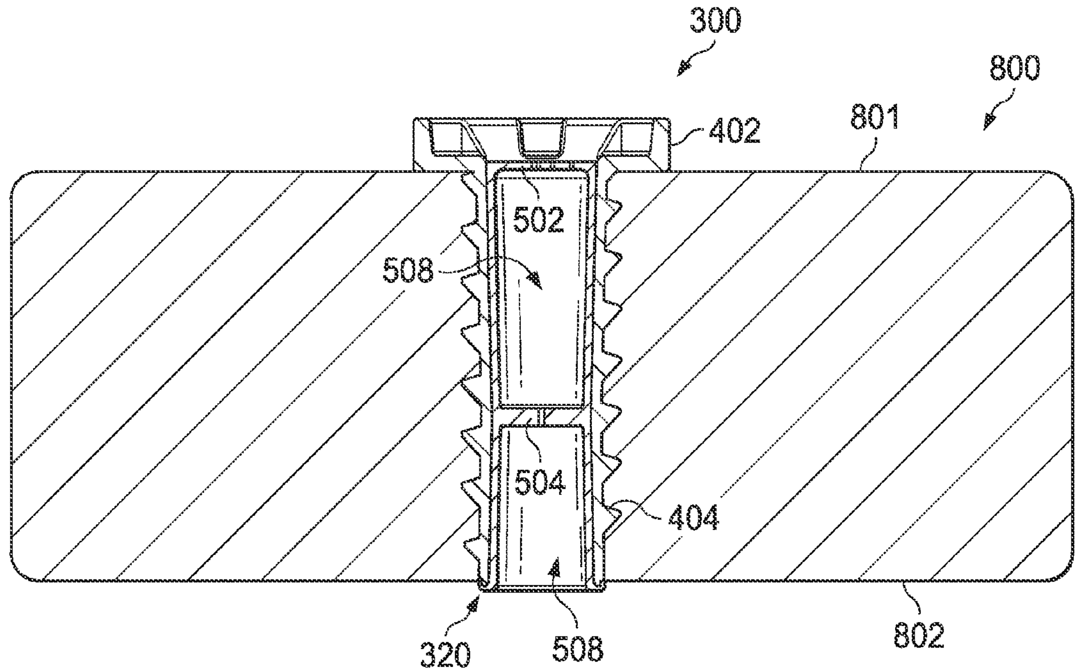

FIG. 17a

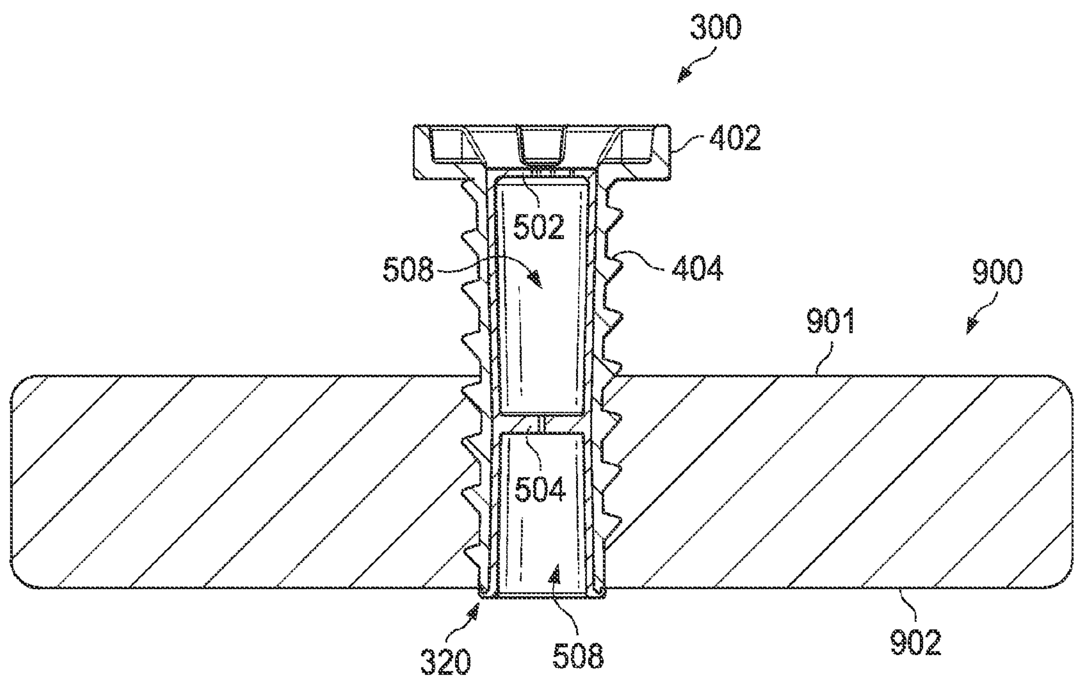

FIG. 17b

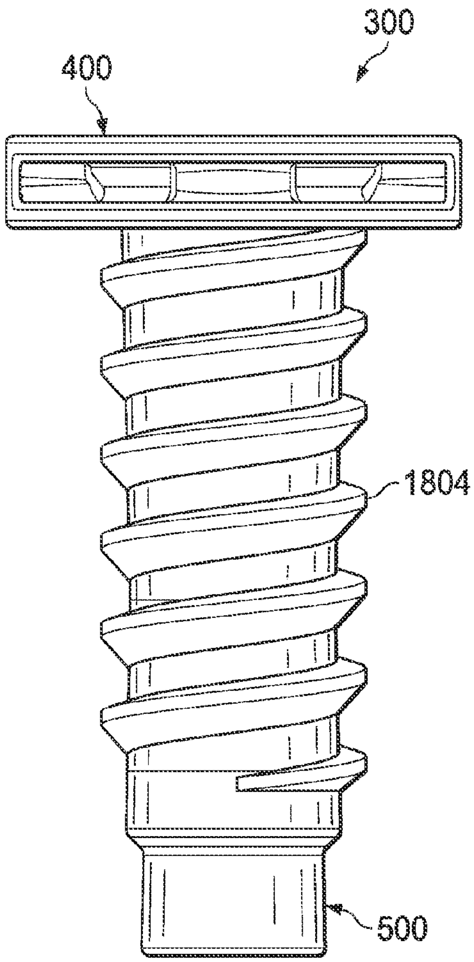

FIG. 18a

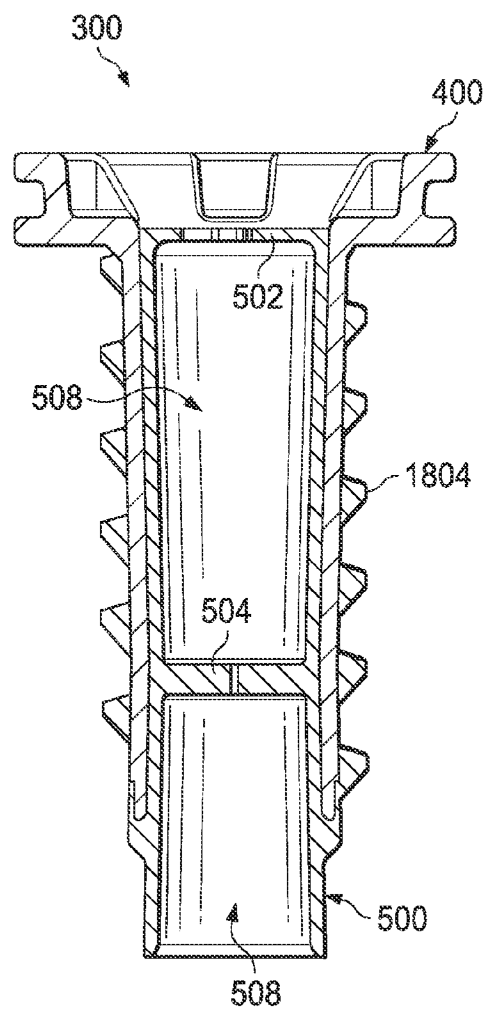

FIG. 18b

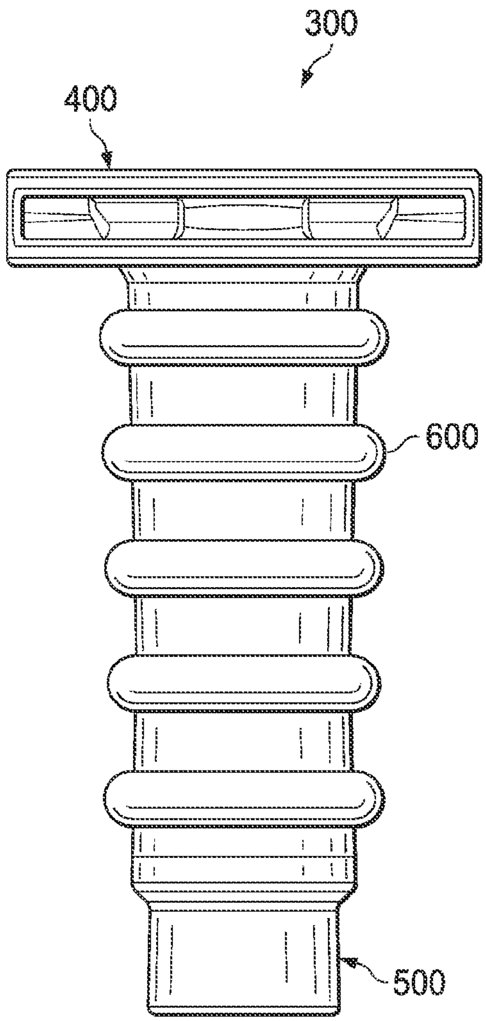

FIG. 19a

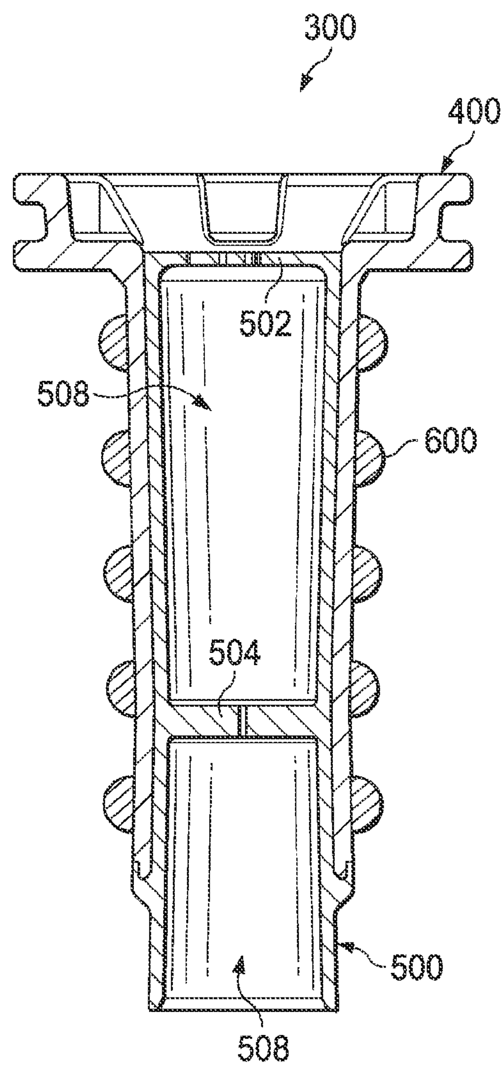

FIG. 19b

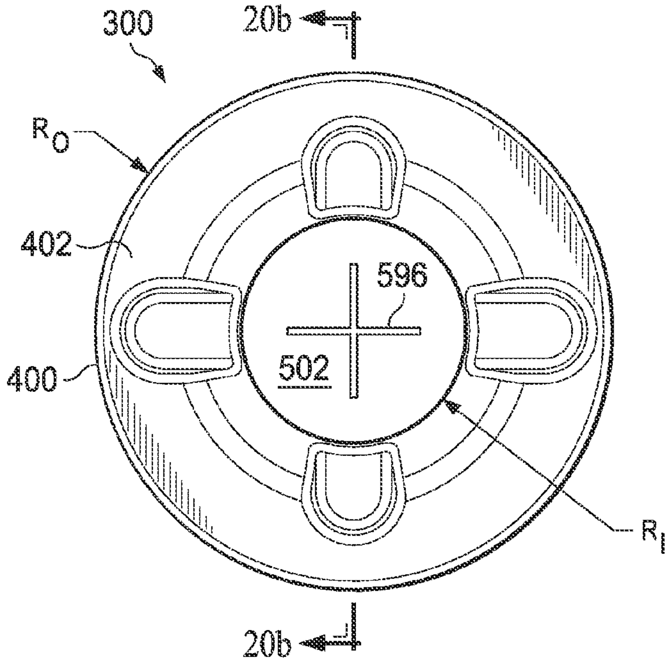

FIG. 20a

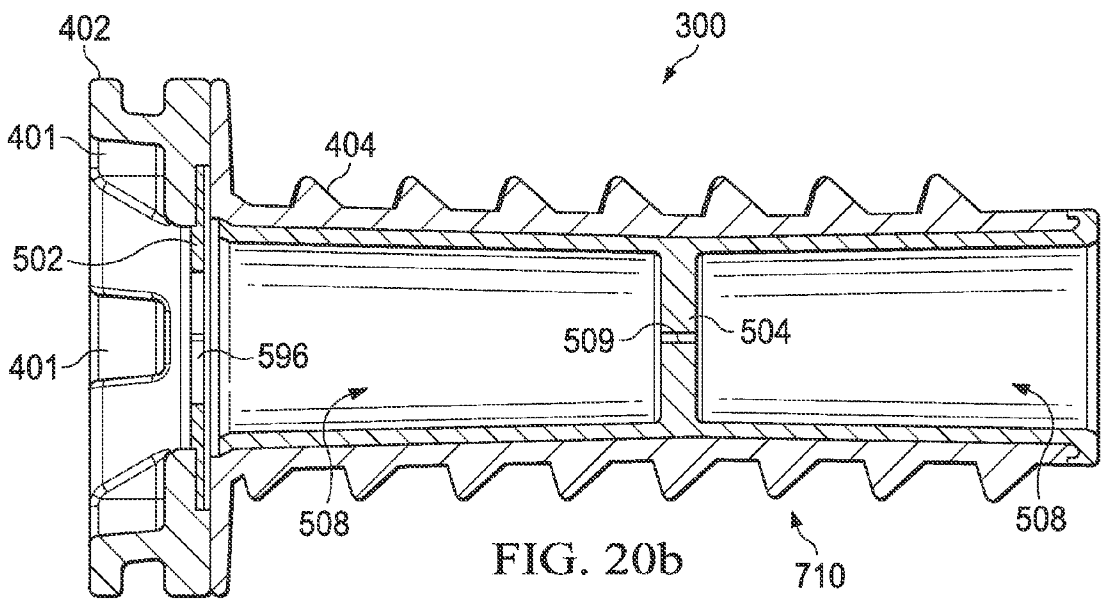

FIG. 20b

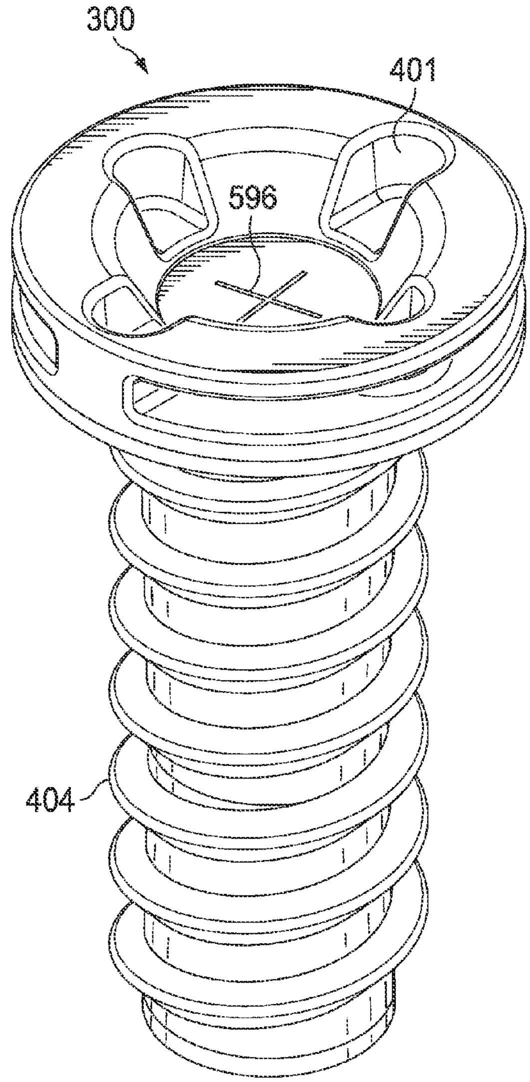

FIG. 20c

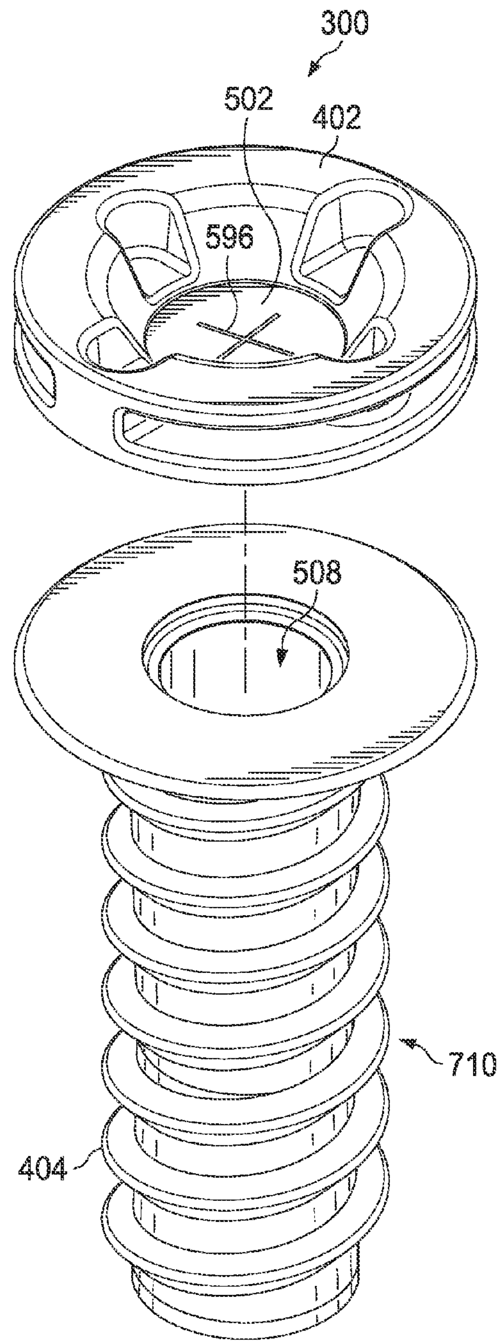

FIG. 20d

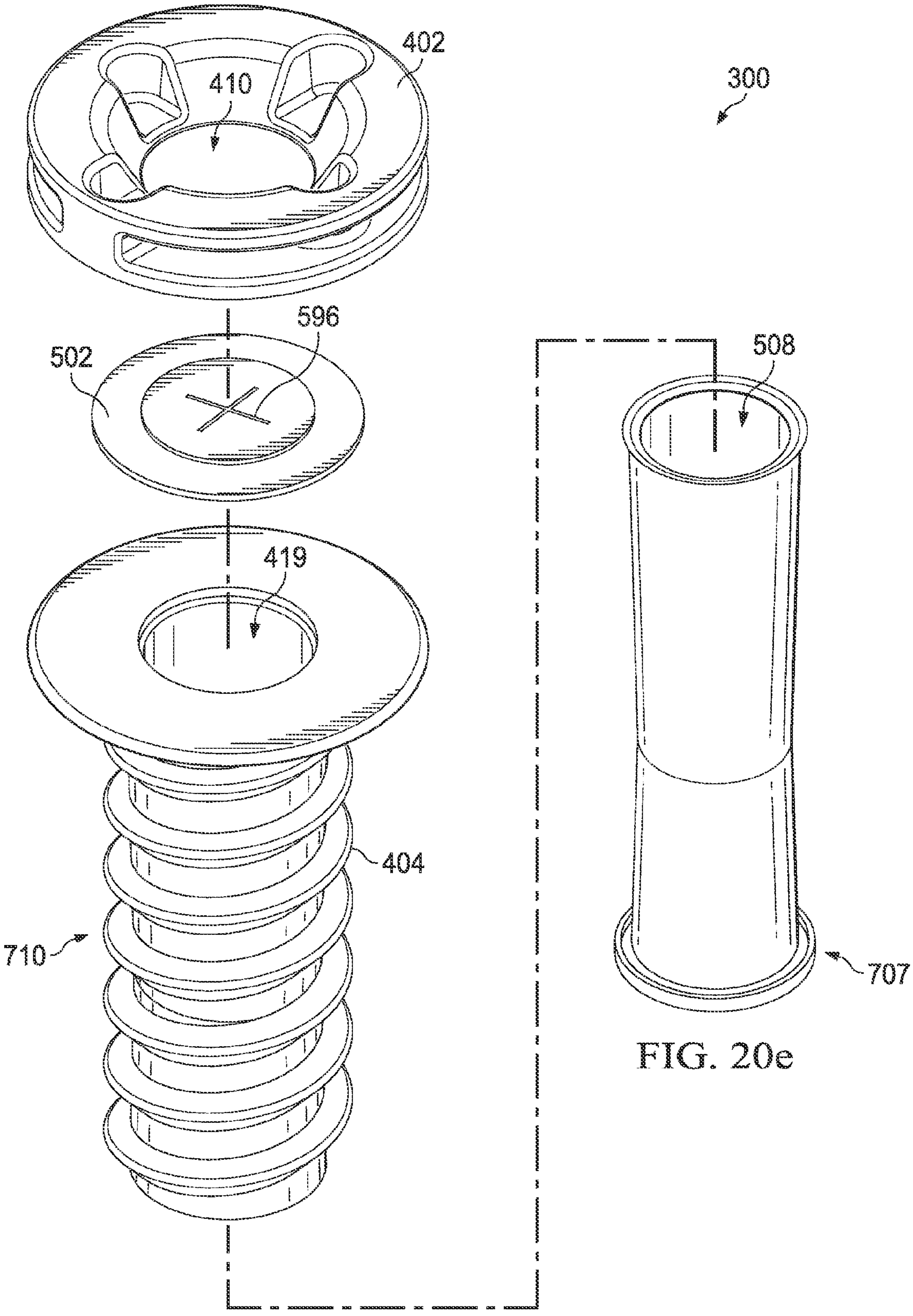

FIG. 20e

HYBRID CANNULA AND METHODS FOR MANUFACTURING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION(S)

This application relates to U.S. patent application Ser. No. 13/749,492, filed Jan. 24, 2013, entitled "HYBRID CANNULA AND METHODS FOR MANUFACTURING THE SAME", which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

This disclosure relates generally to surgical portal devices and, more particularly, to a hybrid cannula having a first portion with a first rigidity overmolded with a second portion with a first flexibility, a third portion with a second rigidity overmolded with a fourth portion with a second flexibility, and the first portion and the third portion coupled together, the hybrid cannula being useful in minimally invasive surgical procedures, including arthroscopic and endoscopic surgeries.

BACKGROUND

It is often preferable to perform a surgery as a minimally invasive surgery (endoscopy or arthroscopy) rather than as an open surgery. Endoscopy and arthroscopy are performed through the use of portals. These portals, made through incisions in the skin and some portion of underlying tissue, are used to fill the abdomen with air, in the case of endoscopy, and the surgical space with fluid, in the case of arthroscopy.

For the duration of this disclosure minimally invasive surgery will be described as it pertains to arthroscopic surgery; however, it is seen that the disclosure extends into endoscopy as well as arthroscopy and the invention disclosed should not be limited to arthroscopy.

A cannula is a medical device having an internal passage (or "cannulation"). A cannula can be inserted into a body, often to create a pathway for elongated instruments to pass into and out of the surgical space. During arthroscopy, as mentioned before, fluid is inserted into the surgical space (such as the shoulder) in order to pressurize and distend the surgical space and improve visualization through the arthroscope. One reason a cannula is inserted into the portal is to prevent this fluid from escaping out of the body.

The cannula functions to prevent fluid from escaping from the surgical space while instruments are inserted through the passage in the cannula as well as when no instruments are located in the cannula. This is typically performed by incorporating a flexible dam with slits into the passage in the cannula.

Cannulas generally consist of a proximal end, an elongated cannulated body, and a distal end.

FIGS. **1***a*-**1***b* and **2***a*-**2***b* depict views of a prior art cannula. A typical cannula **100** is made of a rigid plastic while flexible dams **102***a* and **102***b* are incorporated into the proximal end of the device and held in place by cover **101**. The rigidity of the cannula's elongated body **103** allows the device to simply be threaded using thread **104** through the portals in tissue **10** and positioned over a site, such as depicted in FIG. **2***a*. However, because this type of cannula has a large moment arm (MA), it has a tendency to tip over when instruments are inserted through it, as depicted in FIG. **2***b*. For this reason, cannula **100** often has to be held in place while inserting instruments through the device, which is not desirable.

FIGS. **3***a*-**3***b* and **4** depict views of another approach. Cannula **200** is made of a flexible material, with a passage **219** along elongated body **201** and a flexible dam **205** is incorporated into passage **219** along elongated body **201**. Thin dam **203** may be attached at the proximal end of cannula **200**.

Flexible flanges **202** and **206** are found on the proximal and distal ends of the device, and the length of cannula **200** is approximately the thickness of the skin and some portion of underlying tissue. This device has a tendency to remain in place and upright during instrument insertion. However, the device is inserted through the portal using a non-standard method, which is not desirable. An example of a non-standard method may involve holding the distal end of cannula **200** with the jaws of a grasping tool, advancing the jaws of the grasping tool and the distal end of cannula **200** together into the portal, and opening the jaws of the grasping tool to release cannula **200** from the grasping tool after the distal end of cannula **200** exits the portal and can be detected visually by surgical personnel.

SUMMARY OF THE DISCLOSURE

The disclosed methods and products detailed below serve in part to address the advantages and disadvantages of various types of cannulas described above.

In one broad respect, embodiments of the disclosure may be generally directed to a cannula with a first portion formed from a first material, a second portion formed from a second material, a third portion formed from a third material and a fourth portion formed from a fourth material. The first and third portions may be formed from the same material or a similar material, and the second and fourth portions may be made from the same material or similar materials. The first portion may be formed from a first material having a first rigidity and may be formed with a flange, and have a first passage. The second portion may be formed from a second material having a first flexibility and overmolded to the first portion, the second portion including a membrane. The third portion may be formed from a third material having a second rigidity, and includes a proximal end coupled to the first portion, and a second passage. The fourth portion may be formed from a fourth material having a second flexibility and overmolded to the third portion, the fourth portion including a dam. The first passage and the second passage may be connected to form a single passage along the length of the cannula.

In some embodiments, the second portion is overmolded to the first portion before the first portion and the third portion are coupled. In some embodiments, the fourth portion is overmolded to the third portion before the first portion and the third portion are coupled. In some embodiments, the third portion is coupled to the first portion before the fourth portion is overmolded to the third portion. In some embodiments, the fourth portion is formed to extend beyond a distal end of the third portion. In some embodiments, an outer surface of the third portion includes a thread or ribbing for engaging soft tissue. In some embodiments, the membrane comprises one or more slits. In some embodiments, the first material and the third material may be the same material. In some embodiments, the second material and the fourth material may be the same material.

In another broad respect, embodiments may be generally directed to a method for forming a cannula, including forming a first portion of the cannula from a first material having a first rigidity, forming a second portion of the cannula inside a first passage of the first portion, forming a third portion of the cannula from a third material having a second rigidity, forming a fourth portion of the cannula inside a passage in the third portion, and coupling a proximal end of the third portion to the first portion such that the first passage and the second passage form a cannulation.

In some embodiments, the first portion includes a flange. In some embodiments, the second portion is formed from a second material having a first flexibility and comprises a membrane. In some embodiments, the third portion may include a proximal end and a distal end and a second passage. In some embodiments, the fourth portion may be formed from a fourth material having a second flexibility and has a first dam located approximately halfway along a length of the cannula. In some embodiments, forming the third portion comprises forming a thread or ribbing along an outer surface of the first portion. In some embodiments, forming the second portion of the cannula inside the first portion of the cannula comprises overmolding. In some embodiments, forming the fourth portion of the cannula inside the third portion of the cannula comprises overmolding. In some embodiments, the fourth portion is formed to extend beyond the distal end of the third portion. In some embodiments, the second and fourth materials may be selected for a desired flexibility.

In another broad respect, embodiments may be generally directed to a method including forming a portal in soft tissue in a patient, and advancing a cannula into the portal, the cannula being formed from at least four portions. A first portion may be formed from a first material having a first rigidity, wherein the first portion comprises a flange. A second portion may be overmolded to the first portion, the second portion being formed from a second material having a first flexibility, the second portion comprising a membrane. A third portion may be formed from a third material having a second rigidity, the third portion having a proximal end being coupled to the first portion. A fourth portion may be formed from a fourth material having a second flexibility and overmolded to the third portion, the fourth portion comprising a dam.

In some embodiments, advancing the cannula into the portal comprises engaging the cannula with a tool and rotating the tool to engage a thread or ribbing on the cannula with the soft tissue. In some embodiments, the cannula may be advanced through the portal without rotating the cannula. In some embodiments, advancing the cannula into or through a portal may include a translational movement, a rotational movement, or a combination thereof. In some embodiments, advancing the cannula into the portal comprises positioning the cannula in the portal to position the dam within the soft tissue. Some embodiments may further include advancing one or more instruments through the cannula.

BRIEF DESCRIPTION OF THE DRAWINGS

The following drawings form part of the present specification and are included to further demonstrate certain aspects of the invention. The invention may be better understood by reference to one or more of these drawings in combination with the detailed description of specific embodiments presented herein.

It is to be noted, however, that the appended drawings illustrate only exemplary embodiments of the invention and are therefore not to be considered limiting of its scope for the invention which may admit to other equally effective embodiments. In addition, although the figures may depict embodiments wherein the components represent different devices or locations, they can be combined into a single device or location. Also, a single component may be comprised of a combination of components.

FIG. **1***a* depicts a rigid cannula.

FIG. **1***b* depicts the cannula of FIG. **1***a* in an exploded view.

FIG. **2***a* depicts the cannula of FIG. **1***a* inserted through the soft tissue.

FIG. **2***b* depicts the cannula of FIG. **1***a* inserted through the soft tissue, while the moment placed on it by the force of inserting an instrument through the cannula has caused it to begin to tilt.

FIG. **3***a* depicts a flexible cannula.

FIG. **3***b* depicts the cannula of FIG. **3***a* in an exploded view.

FIG. **4** depicts a cross-sectional view of the cannula of FIG. **3***a*.

FIG. **5** depicts an isometric view of one embodiment of a hybrid cannula.

FIG. **6** depicts an exploded view depicting portions of one embodiment of a hybrid cannula.

FIGS. **7***a* and **7***b* depict a top view and a cross-sectional view of one embodiment of a hybrid cannula.

FIGS. **8***a* and **8***b* depict a top view and a cross-sectional view of a portion of one embodiment of a hybrid cannula.

FIGS. **9***a* and **9***b* depict a cross-sectional view and a top view of another portion of one embodiment of a hybrid cannula.

FIG. **10** depicts a flow diagram of one example method of manufacturing a hybrid cannula.

FIG. **11** depicts an isometric view of one embodiment of a hybrid cannula.

FIG. **12** depicts an exploded view depicting portions of one embodiment of a hybrid cannula.

FIGS. **13***a* and **13***b* depict a top view and a cross-sectional view of one embodiment of a hybrid cannula.

FIG. **14** depicts an isometric view of one embodiment of a hybrid cannula.

FIGS. **15***a* and **15***b* depict a top view and a cross-sectional view of one embodiment of a hybrid cannula.

FIG. **16***a* depicts a side view of one embodiment of a hybrid cannula and a tool useful for inserting a cannula.

FIG. **16***b* depicts a side view of one embodiment of a hybrid cannula coupled with a tool useful for inserting a cannula.

FIG. **17***a* depicts a cross-sectional view of one embodiment of a hybrid cannula inserted through thick soft tissue.

FIG. **17***b* depicts a cross-sectional view of one embodiment of a hybrid cannula inserted through thin soft tissue.

FIGS. **18***a* and **18***b* depict side and cross-sectional views of one embodiment of a hybrid cannula.

FIGS. **19***a* and **19***b* depict side and cross-sectional views of one embodiment of a hybrid cannula.

FIGS. **20***a*-**20***e* depict top, cross-sectional, isometric and exploded views of one embodiment of a hybrid cannula.

DETAILED DESCRIPTION

Embodiments of hybrid cannulas disclosed herein can overcome the shortcomings of conventional cannulas. Using manufacturing methods not traditionally utilized for cannulas, a new device may be created to have the ability, among others, to remain stable during instrument insertion and to be inserted through the portal using traditional methods. Those skilled in the art will recognize that the invention can be used in both arthroscopic and endoscopic surgery without departing from the spirit or scope of the invention.

Referring first to FIG. **1***a*, a typical arthroscopic cannula **100**, which is fully assembled, is depicted. Most generally, arthroscopic cannula **100** consists of distal end **110**, cover **101**, and proximal end **105** where functioning dams **102***a* and **102***b* are attached to the device, as shown in FIG. **1***b*. FIG. **1***b* depicts an exploded view of cannula **100**.

The following steps outline a general method for manufacturing cannula **100**, although variations to this method may exist.

The cannula's elongated body **103** and cover **101** may be manufactured separately from a similar rigid material using, for instance, separate single-shot molding processes. Elongated body **103** may be formed with stop cock **107** to accommodate attachments such as inflow or outflow pump tubing. Dams **102***a* and **102***b* may be manufactured from a flexible material and function to prohibit fluid from passing through cannula **100**. Flexible dams **102***a* and **102***b* may be made in various ways. For example, dams **102***a* and **102***b* can be manufactured via molding and/or die cutting processes. In a molding process, dams **102***a* and **102***b* are first molded. Slits **108** and **109** are then created in dams **102***a* and **102***b*. In a die cutting process, a flat sheet of flexible material such as rubber is cut into a circular shape using a die. The die may also cut slits **108** and **109** into dams **102***a* and **102***b*, or a secondary slitting operation could be used to create slits **108** and **109** in dams **102***a* and **102***b*. Die cutting the flexible material may be the preferred method to manufacture dams **102***a* and **102***b* because it is a relatively inexpensive process as compared to molding.

Traditionally, cannula **100** components are assembled and fixed together using methods such as adhesion and/or mechanical fixation. It is important to note that elongated body **103**, dams **102***a* and **102***b*, and cover **101** must be assembled together in a secondary operation. Specifically, the axis of dam **102***a* is rotationally offset from the axis of dam **102***b* so that the dams' slits **108** and **109** are not aligned. Dams **102***a* and **102***b* are placed between elongated body **103** and cover **101**. Elongated body **103** and cover **101** are rigidly fixed to one another using any number of fixations including but not limited to adhesives or mechanical fixation.

Referring next to FIG. **3***a*, another arthroscopic cannula **200** may be flexible and have flanges on both ends. In FIG. **3***b*, an exploded view of cannula **200** exposes components of which cannula **200** comprises. Elongated body **201** with flanges **202** and **206**, and thin dam **203** are typically made from the same material, which may be a flexible rubber, silicone, or the like. FIG. **4** depicts a cross-sectional view of cannula **200**, showing dam **205** positioned inside passage **219** in elongated body **201**.

The following steps outline a general method for manufacturing cannula **200**, although variations to this method may exist.

Cannula **200** may be manufactured by a single shot molding process. The mold from the single shot molding process includes features to account for flanges **202** and **206** as well as dam **205**, which is integral to elongated body **201**. As a result of this single shot molding process, dam **205** and elongated body **201** must be manufactured from the same flexible material, such as rubber, silicone, or the like. This allows for dam **205** to remain flexible and maintain similar properties as dams **102***a* and **102***b* in cannula **100**. Additionally, using this process enables dam **205** to be integral to elongated body **201** and be located inside passage **219** of elongated body **201**. After molding, a secondary slitting operation is then used to create slits in dam **205**. Thin dam **203** may be manufactured from a number of processes. One process is to mold thin dam **203** with a small aperture **204** or die cut small aperture **204** after molding thin dam **203**, while a second method is to die cut thin dam **203** with a small aperture **204** from a sheet of flexible material such as rubber.

Thin dam **203** may be attached to flange **202** on elongated body **201**. This may be accomplished by any number of chemical, mechanical, or thermal methods, including but not limited to a mechanical fit.

Cannula **200** is characterized by several disadvantages. Some of these disadvantages include cannula **200** may be too flexible for use with traditional insertion procedures, cannula **200** may move up and down within the portal during instrument insertion and/or removal, or the like.

Common features of both cannula **100** and cannula **200** are the flexible dams. In the case of the rigid cannula **100**, general practice is to assemble dams **102***a* and **102***b* to rigid parts **101** and **103** of cannula **100** using secondary operations. In the case of flexible cannula **200**, elongated body **201** and flanges **202** and **206** are molded from the same material as dam **205**, eliminating the need to assemble dam **205** to elongated body **201**. As will be shown below, embodiments disclosed herein leverage manufacturing methods not typically used in manufacturing cannulas, in order to create a device which can provide some of the advantages of cannula **100** and cannula **200** without some of their respective drawbacks.

In one embodiment, a hybrid cannula may include a rigid portion with a flexible portion formed with a dam and/or membrane in an internal passage of the cannula. The flexible portion may be overmolded onto the rigid portion. In one embodiment, the rigid portion and the flexible portion may partially overlap as a result of an overmolding process.

One example of a hybrid cannula is depicted in FIG. **5**. Hybrid cannula **300** may comprise proximal end **310** and distal end **320**. An exploded view of hybrid cannula **300** is depicted in FIG. **6**. First portion **400** of hybrid cannula **300** may be made of a material with selected rigidity so that it is rigid enough to be easily inserted or positioned in a patient using traditional insertion methods, and may be formed to have an elongated shape or profile from proximal end **310** to distal end **320** (as seen in FIG. **5**). Second portion **500** of hybrid cannula **300** may be flexible and contain one or more features to prevent fluid leakage and/or squirting.

FIGS. **7***a* and **7***b* depict a top view and a cross-sectional view of hybrid cannula **300** in which second portion **500** may be formed partially inside first portion **400**. This may be established in any number of ways including but not limited to overmolding second portion **500** to first portion **400**. As depicted in FIGS. **7***a* and **7***b*, hybrid cannula **300** having passage **508** formed therein may include first portion **400** which may include an outer surface formed with thread **404** and flange **402** having outer radius R_O and having inner radius R_I. The ratio of R_O/R_I may be selected to minimize the overall size of hybrid cannula **300** while still maintaining its structural integrity. In some embodiments, the ratio may be selected to minimize the overall size of flange **402**.

Second portion **500** may be formed from various materials. Second portion **500** may be formed in first portion **400** and include dam **504** having slit(s) **509**, thin membrane **502**, and walls **503***a* and **503***b*. Dam **504** may have a thickness t_D, thin membrane **502** may have a thickness t_M, and walls **503***a* and **503***b* may have a thickness t_W. Thin membrane **502** may be formed with slots **506** and positioned at proximal end **310***b*. Opening **507** may also be formed in membrane **502**. Opening **507** and slots **506** may be configured to allow for a core pin or tool necessary for molding to maintain structural integrity during the manufacturing process. As depicted in FIG. **7***a*, dam **504** may be visible through opening **507**, including slits **509**. Opening **507** and slot(s) **506** and slits **509** may be aligned about a central or longitudinal axis A, and dam **504** and thin membrane **502** may be oriented relative to each other such that slots **506** and slits **509** do not align. Distal end **320***b* of second portion **500** may or may not extend over distal end **320***a* of first portion **400**. Additionally, proximal end **310***b* of second portion **500** may or may not extend past proximal end **310***a* of first portion **400**.

Hybrid cannula **300** may be manufactured to a number of different overall lengths. A correctly sized length of hybrid cannula would be selected for use during the arthroscopy based on the thickness of the soft tissues that the portal extends through.

FIGS. **8***a* and **8***b* depict a top view and a cross-sectional view of first portion **400** of hybrid cannula **300**. Embodiments of first portion **400** may extend between proximal end **310***a* and distal end **320***a* of hybrid cannula **300**. Additionally, there may be flange **402** at proximal end **310***a* and thread(s) **404** along the outside of first portion **400**.

First portion **400** of hybrid cannula **300** may be composed of one material or several materials. Additionally, each feature of first portion **400** may be made of only one material or of several materials. The materials of each feature may be flexible, rigid, or semi-rigid. Examples of rigid materials that may be used in first portion **400** and may be appropriate for use in surgery may include, but are not limited to polycarbonate, polyetheretherketone (PEEK), and acrylonitrile butadiene styrene (ABS). Examples of flexible materials that may be used in first portion **400** may be appropriate for use in surgery and may include, but are not limited to, silicone, thermoplastic elastomer, polyurethane, and rubber. Other materials may be used for overmolding onto, for example titanium and stainless steel. For both flexible and rigid materials, it may be beneficial for the material to include colorants and/or to be partially transparent. Plastic or stainless steel are generally accepted by the orthopedic community. Some embodiments of hybrid cannula **300** disclosed herein can be lighter in weight than a conventional cannula, such as cannula **100**. The reduction in weight of hybrid cannula **300** relative to cannula **100** may be caused by the elimination and/or size reduction of one or more features of cannula **100**. For example, hybrid cannula **300** may not include a stop cock such as stop cock **107** of cannula **100**. As another example, selected for the same patient, hybrid cannula **300** may be shorter in length relative to cannula **100**.

Proximal end **310** of hybrid cannula **300** may include flange **402**. Hybrid cannula **300** can be inserted in a manner similar to cannula **100** described above, and various features of hybrid cannula **300** can provide several additional advantages. For example, flange **402** at proximal end **310** of hybrid cannula **300** may prevent hybrid cannula **300** from being over inserted by providing a surface **411** to press against the skin, stopping hybrid cannula **300** from being inserted further than the base of flange **402**. Additionally, flange **402** provides a surface for features **401** which allow an insertion instrument (an example is depicted in FIGS. **16***a* and **16***b*, discussed below) to contact hybrid cannula **300** and insert it through the portal. Features **401** may be any size or shape which allows for an opposing shape or complimentary feature on an insertion instrument to insert and provide a resistance to the torque and/or force placed on hybrid cannula **300** during insertion of hybrid cannula **300** through the portal. Additional advantages will be apparent to those skilled in the art.

First portion **400** may be cannulated or otherwise include passage **419** with opening **410** to allow instruments to pass through during arthroscopy. Inner surface **406** may also be appropriately shaped for material to adhere to it. Additionally, first portion **400** may or may not be uniformly thick and could have a number of features built into inner surface **406** or outer surface **407**, including but not limited to ribbing, holes, steps, threads, and slots.

External threads **404** may function to aid in insertion threading of hybrid cannula **300** into the soft tissue surrounding the portal. Additionally, external threads **404** may function to hold hybrid cannula **300** in place in the soft tissue throughout the surgery, including during instrument insertion and removal. External threads **404** may start at or near flange **402** and may lead out of the hybrid cannula at or near distal end **320***a* of first portion **400**. External threads **404** may start any distance past flange **402** and end any distance before distal end **320***a*. For example, one skilled in the art would appreciate that in some applications it would be beneficial for only the portion near distal end **320***a* to contain external threads. External threads **404** shown may have a constant pitch and profile; however, a variable pitch and/or a variable profile of external threads **404** could be used to aid in engaging the soft tissue. Additionally, angle Θ_S of profile of external threads **404** may be generally perpendicular to or angled relative to longitudinal axis A. Additionally, the profile of thread **404** may be any shape including but not limited to trapezoidal, circular, rectangular, triangular, ovular, and asymmetric shapes.

FIGS. **9***a* and **9***b* depict a cross-sectional view and a top view of second portion **500** of hybrid cannula **300**. Second portion **500** may comprise proximal end **310***b*, body regions or bodies **503***a*-**503***b*, and distal end **320***b*. Second portion **500** may include passage **508** from thin membrane **502** at proximal end **310***b* along the length of hybrid cannula **300** to opening **511** at distal end **320***b*. The inner diameter of passage **508** may be constant along the length of second portion **500** or may vary. In some embodiments, the inner diameter of passage **508** may vary due to thickness t_w of walls **503***a* or **503***b*. In some embodiments, the inner diameter of passage **508** may vary due to the inner diameter of first portion **400**.

At proximal end **310***b* of second portion **500**, membrane **502** (also referred to as a squirt membrane) may be found. Thickness t_M of membrane **502** can be of any suitable thickness, depending upon the elasticity, durometer, and/or strength of the material used. Examples of a suitable thickness may range from about 0.25 mm to about 2 mm. Thickness t_M of the membrane can be about the same as or less than thickness t_D of dam **504**.

A purpose of squirt membrane **502** may include preventing fluid from being expelled from ("squirting out of") hybrid cannula **300** during instrument insertion or removal. For example, when an arthroscopic instrument is passed through or removed from hybrid cannula **300** the pressure behind dam **504** may cause fluid to squirt through dam **504** and around the instrument. Squirt membrane **502** may provide a secondary surface to prevent the fluid from exiting proximal end **310***b* of hybrid cannula **300** and striking the surgeon. The thickness t_M of squirt membrane **502** may be small to prevent significant resistance to the arthroscopic instrument when the instrument is inserted through the device. Squirt membrane **502** may be flexible so that the movement of the instrument within hybrid cannula **300** is not restricted.

As illustrated in FIG. **9***a*, dam **504** may be positioned in passage **508** between proximal end **310***b* and distal end **320***b* of second portion **500**. The thickness of the dam can be about the same as or more than the thickness of squirt membrane **502** described above. At distal end **320***b* of second portion **500** of hybrid cannula **300**, a feature which may allow second portion **500** to be molded throughout the entire length of first portion **400** may be found. For example, protrusion **707** at distal end **320***b* may be a feature that can be used as a seal-off during overmolding of second portion **500** onto first portion **400**. It can be appreciated that a number of different types of seal-offs may be used distal or proximal to dam **504** in order to overmold second portion **500** onto first portion **400**. A seal off may be on squirt membrane **502** during overmolding as well. In embodiments in which the squirt membrane is not present, seal-offs may be on walls **503***a* and **503***b*, both distal and proximal to dam **504**.

Second portion **500** of hybrid cannula **300** may be composed of one material or several materials. The materials of each feature may be flexible, semi-rigid, or rigid. Examples of these flexible and semi-rigid materials that may be used to manufacture second portion **500** and may be appropriate for use in surgery include, but are not limited to, silicone, thermoplastic elastomer, polyurethane, and rubber. Examples of rigid materials that may be used in second portion **500** and may be appropriate for use in surgery may include, but are not limited to polycarbonate, polyetheretherketone (PEEK), and acrylonitrile butadiene styrene (ABS). Other materials may be overmolded onto, for example titanium and stainless steel. It may also be beneficial for the materials to include colorants and/or to be partially transparent.

In second portion **500**, squirt membrane **502** and dam **504** may be connected by body region **503***a*. However, it may be found in some embodiments of second portion **500** body regions **503***a*-**503***b* may not connect one feature to another. For example, in one embodiment possibility, protrusion **707** may be connected to dam **504** by body region **503***b*, but squirt membrane **502** might not be connected to dam **504** by body region **503***a*. Therefore, dam **504** and squirt membrane **502** may be formed during two separate processes.

As mentioned above, proximal end **310***b* may include squirt membrane **502**. An advantage of squirt membrane **502** is that it may prevent fluid from squirting out of hybrid cannula **300** during instrument insertion or removal. When an arthroscopic instrument is passed through hybrid cannula **300**, fluid pressure behind dam **504** may cause fluid to squirt through dam **504** and around the instrument. Squirt membrane **502** may be thin and present little resistance to the arthroscopic instrument when the instrument is inserted through or removed from passage **508** of hybrid cannula **300**. Squirt membrane **502** may be flexible so that the movement of instruments within passage **508** of hybrid cannula **300** is not restricted. Additionally, slots **506** may be created through squirt membrane **502** so that instruments may pass through squirt membrane **502**. As depicted in FIG. **9***b*, squirt membrane **502** may be formed with opening **507** and/or with slots **506**. Opening **507** and slots **506** may individually or together combine to have any shape, length, thickness, orientation, and combination thereof, including but not limited to triangle-like slits, a circular hole, a straight slit, an ovular opening, slots and knife slits.

In one embodiment of hybrid cannula **300**, body **503***a*-**503***b* of second portion **500** may be integral with one or more of squirt membrane **502**, dam **504**, and protrusion **707**. Body **503***a* or **503***b* may be sufficiently strong to hold membrane **502** or dam **504** and/or to more securely attach second portion **500** to first portion **400**. Also, thickness t_W of body **503***a* or **503***b* may be thin so that the inner diameter or cannulation of second portion **500** remains as large as possible to allow for a variety of diameters of arthroscopic instruments to pass through hybrid cannula **300**.

Dam **504** may prevent fluid from passing through hybrid cannula **300** during, before, and after arthroscopic instruments are passed through hybrid cannula **300**. Dam **504** may be preferably thick enough to prevent fluid from leaking but not so thick that it is difficult for the surgeon to pass the arthroscopic instruments through dam **504**. Dam **504** may contain openings such as slits **509** to allow instruments to pass through dam **504**. These openings flex around an instrument when an instrument is passed through dam **504** and close when dam **504** is in its stable state. These openings in combination with the shape of dam **504** may take the form of any number of shapes, lengths, thicknesses, orientations, and combination thereof, including but not limited to, circular hole(s), ovular opening(s), knife slit(s), tri-slits, duck bill(s), straight slit, quad-slits, overlapping flaps, and small aperture(s). These slits may preferably be long enough to allow instruments to pass though dam **504** without damaging dam **504**, even when the instrument has a diameter only slightly smaller than the inner diameter of passage **508** of hybrid cannula **300**. Although only one dam **504** is shown in this configuration of second portion **500** of hybrid cannula **300**, an embodiment of a hybrid cannula may comprise two or more dams to be located within second portion **500** thereof.

Additionally, the location of dam **504** within the length of hybrid cannula **300** may be anywhere within passage **508** of second portion **500** but may preferably be distal to squirt membrane **502**. In one embodiment, dam **504** may be located near the middle of hybrid cannula **300** between proximal end **310***b* and distal end **320***b* of second portion **500**. The dam location may determine the length of the moment arm acting on the hybrid cannula during instrument insertion and removal. It may be preferable that dam **504** be located in hybrid cannula **300** such that dam **504** can be positioned at or below the level of the skin, no matter how deep hybrid cannula **300** is inserted. However, if dam **504** is too close to distal end **320** of hybrid cannula **300**, when articulating instruments are opened, significant leaking or squirting may occur.

The following steps outline a general method for manufacturing hybrid cannula **300**, although variations to this method may exist. Embodiments disclosed herein may be manufactured using different processes to produce hybrid cannula **300** having a substantially rigid first portion **400** and substantially flexible second portion **500** with passage **508** which may include dam **504**, squirt membrane **502**, and other features included therein.

Hybrid cannula **300** may be manufactured by overmolding second portion **500** onto first portion **400**, so that no additional assembly is needed. The process of overmolding allows for a cannula with a substantially rigid body composed of one material and a dam composed of another material to be manufactured without the need to secondarily assemble the dam to the body of the cannula.

FIG. **10** depicts a flow diagram illustrating one example method for manufacturing a hybrid cannula. In step **1010**, a material may be selected for first portion **400** of hybrid cannula **300**. As mentioned above, first portion **400** may be manufactured from materials selected for a desired rigidity, with selected features such as threads **404**, flange **402**, and the like on the outer surface, and may include steps, tapers, surface roughness or other features on the inner surface for contact with second portion **500**. The selection of one or more materials for first portion **400** may depend on one or more of an intended length of hybrid cannula **300**, a desired inner diameter of hybrid cannula **300**, a surgical procedure in which hybrid cannula **300** is to be used, an expected fluid pressure, and the like. Material selection may also factor in weight or density of a material, radioluminescence, color, and transparency.

In step **1020**, first portion **400** is manufactured, such as by injection molding or other processes for shaping plastic, metals, ceramic materials or other biocompatible materials known and applicable to biomedical components. In some embodiments, first portion **400** is manufactured through liquid injection molding of a rigid plastic using any number of core pins and mold cavities. For example, material may be injected into a mold and cooled or cured to produce first portion **400** having selected features. After first portion **400** has been molded, the core pins are removed. Steps **1010** and **1020** may be repeated as necessary until all features are formed in first portion **400**. First portion **400** may undergo secondary processes such as machining or texturing as preparation for joining with second portion **500**.

In step **1030**, a material may be selected for second portion **500**. Second portion **500** may be manufactured from one or more materials selected for a desired flexibility, smoothness, surface friction, elasticity and the like and for contact with first portion **400**.

In step **1040**, first portion **400** may be positioned in a second mold. New core pins may be placed into first portion **400** so that an open space remains between first portion **400** and the core pins, except at the points where second portion **500** is meant to begin and end against first portion **400**, in order to create the desired features which may include squirt membrane **502** and/or dam **504** features. As an example, in one embodiment, the selected material can be liquid injection molded into empty space in first portion **400** through the process of overmolding. Steps **1030** and **1040** may be repeated as necessary until all features are formed in second portion **500**. The material forming second portion **500** adheres to first portion **400**, and the core pins are removed from the device leaving second portion **500** permanently fixed to first portion **400**. Secondary operations on hybrid cannula **300** may include, but are not limited to, slitting dam **504** located in second portion **500**. Further machining or manufacturing processes may be used to customize hybrid cannula **300** for a particular use or patient.

Other embodiments of hybrid cannula **300** may provide additional features, including features relating to a distal end. Example features that may be included in embodiments of hybrid cannula **300** will now be described.

FIG. **11** depicts an embodiment of hybrid cannula **300**, which comprises similar features as discussed above, and further includes portion **360** of second portion **500** extending beyond the distal tip of first portion **400**. Portion **360** may be flexible, semi-rigid, transparent, or have some other characteristic different than the distal tip of first portion **400**. In some embodiments, hybrid cannula **300** having portion **360** may allow first portion **400** to be reduced in length, which may be advantageous during insertion, surgery, or removal.

FIG. **12** depicts an embodiment of hybrid cannula **300** as seen in FIG. **11**, in which second portion **500** may include portion **360** having transition section **363**. Transition section **363** may provide additional adhesion between second portion **500** and first portion **400**, as well as provide a seal off feature which may be necessary for the overmolding process. In one embodiment, dam **504** may be located at seam **515** of second portion **500**. The distance between seam **515** and transition section **363** or distal end **320***b* may be shorter than the distance between, for example, dam **504** and proximal end **310***b* (see FIG. **7***b*).

FIGS. **13***a* and **13***b* depict a top view and a cross-sectional view of an embodiment of hybrid cannula **300** as seen in FIGS. **11** and **12** in which distal end **320***b* of second portion **500** has been extended past distal end **320***a* of first portion **400**. It may be preferable for end portion **360** to be manufactured from a flexible material described previously. This may allow the surgeon to open articulating instruments while part of the functional tip of the articulating instrument is located within hybrid cannula **300**. End portion **360** may stretch and expand while the instrument is articulating. It may be preferable for end portion **360** to be flexible enough for the material to easily stretch during instrument articulation but strong enough to prevent tearing of the material. The range of flexibility is dependent upon the material. Likewise, the distance that end portion **360** at distal end **320***b* of second portion **500** extends past distal end **320***a* of first portion **400** may vary from implementation to implementation.

FIG. **14** depicts an isometric view of an embodiment of hybrid cannula **300** having flange **365** formed at the distal end of second portion **500** (see FIG. **15***b*) and thread **404** extending only partially along the length of first portion **400**.

FIGS. **15***a* and **15***b* depict a top view and a cross-sectional view of an embodiment of hybrid cannula **300** as seen in FIG. **14** in which second portion **500** includes flange **365** extending past first portion **400**. It may be preferable that second portion flange **365** be manufactured from a flexible material described previously. Flange **365** may ensure that hybrid cannula **300** remains flush to the inner surface of the soft tissue. Flange **365** may have the benefit of staying out of the surgical space as well as potentially improving the field of vision in the surgical space. Flange **365** may have any diameter or shape including but not limited to circular, triangular, and fan shapes and may be beveled or otherwise shaped to allow ease of insertion or removal from a patient. Flange **365** may be thin enough to fold up along the sides of first portion **400** when hybrid cannula **300** is inserted through a portal. Flange **365** may be strong enough not to tear and to hold its original shape once hybrid cannula **300** has been inserted. Additionally, flange **365** may include slits or gaps (not shown) to aid flange **365** in folding up along the sides of first portion **400** when hybrid cannula **300** is inserted through a portal.

On first portion **400** of hybrid cannula **300** thread **404** may terminate near to or away from the distal end of first portion **400**. Additionally, second portion **500** of hybrid cannula **300** may extend past external threads **404**. External threads **404** may hold hybrid cannula **300** in the soft tissue while the distal end of first portion **400** of hybrid cannula **300** may allow a smooth surface for flange **365** to rest against during insertion of hybrid cannula **300** through the portal. This may prevent excessive protruding of flange **365** against first portion **400** of hybrid cannula **300** during insertion of the device through the portal.

FIGS. **16***a* and **16***b* depict side views of one embodiment of hybrid cannula **300** and an obturator **90** (also referred to as a trochar or dilator) useful for inserting hybrid cannula **300** into a patient. As seen in FIG. **16***a*, obturator **90** may have a central shaft **91** having a length such that end **92** extends beyond a distal end of hybrid cannula **300**, and end **92** may be pointed or otherwise shaped for ease of insertion through the soft tissue. Features **93** on obturator **90** may engage hybrid cannula **300** such that by rotating obturator **90** about a central or longitudinal axis, threads **404** of hybrid cannula **300** may engage the soft tissue and advance hybrid cannula **300** into position. Obturator **90** may also be used to remove hybrid cannula **300** or adjust positioning or orientation of hybrid cannula **300** during use. Other insertion methods may be utilized. For example, a long thin metal rod (referred to as a switching stick) is placed through an incision in the skin. The hybrid cannula is placed over the cannulated obturator (the obturator has a hole along its axis). The assembled hybrid cannula and obturator are placed over the switching stick and the hybrid cannula is threaded, pushed or otherwise advanced into the soft tissue. The switching stick is removed and the obturator is removed, leaving the hybrid cannula behind.

Attention is now turned to FIGS. **17***a*-**17***b* which may exemplify the final position of hybrid cannula **300** after inserting it through the soft tissue. Other after-insertion positions of hybrid cannula **300** may also be possible and anticipated. FIG. **17***a* depicts soft tissue **800** having outer surface

801 and inner surface 802. FIG. 17*b* depicts soft tissue 900 with outer surface 901 and inner surface 902. It can be seen that soft tissue 800 in FIG. 17*a* is thicker than soft tissue 900 in FIG. 17*b*. In both cases, hybrid cannula 300 is shown inserted through the portal made in soft tissues 800 and 900 and, in both cases, dam 504 is located below outer surface 801 or 901 of the soft tissue. This may decrease the moment arm of hybrid cannula 300 and may further prevent the hybrid cannula from falling over, thereby solving a problem common in cannula 100. The moment arm generally refers to the distance from the center of the soft tissue to the point at which an instrument places force on hybrid cannula 300. The location of dam 504 may determine or at least influence the location of the force causing the moment arm.

In one embodiment of hybrid cannula 300, such as depicted in FIG. 17*a*, proximal flange 402 of hybrid cannula 300 may fit flush against outer surface 801 of soft tissue 800 while distal end 320 of hybrid cannula 300 just extends past inner surface 802 of soft tissue 800. In this case, hybrid cannula 300 is just long enough to be used. If soft tissue 800 is thicker, a longer hybrid cannula 300 may need to be used.

In one embodiment of hybrid cannula 300, such as depicted in FIG. 17*b*, proximal flange 402 of hybrid cannula 300 abuts or is proximal to outer surface 901 of soft tissue 900 while distal end 320 of hybrid cannula 300 just extends past inner surface 902 of soft tissue 900. In this case, hybrid cannula 300 fits the soft tissue since external threads 404 are engaging soft tissue 900, distal end 320 of hybrid cannula 300 extends just past inner surface 902 of soft tissue 900, and dam 504 of hybrid cannula 300 remains subcutaneous, subdermal, intramuscular, or otherwise beneath outer surface 901 of soft tissue 900. If soft tissue 900 is thinner, a shorter hybrid cannula 300 may need to be used in order for the dam to remain subcutaneous, subdermal, intramuscular, or otherwise beneath outer surface 901 of soft tissue 900.

One method for using hybrid cannula 300 may involve preparing the surgical site. For example, an x-ray, MRI, or other imaging system may be used to determine the thickness of soft tissue 900 and other tissue near the desired surgery site. Depending upon the thickness of soft tissue, hybrid cannula 300 may be selected or prepared accordingly for insertion. In some embodiments, a kit may include different lengths, inner diameters of a passage, dam positions, dam thicknesses, squirt membrane thicknesses, etc. of hybrid cannula 300.

Selection of a desired hybrid cannula 300 may be based on a feature of hybrid cannula 300. For example, a hybrid cannula 300 may be selected to ensure that a dam is positioned at some point in the tissue, such as approximately half way, close to the surface, close to the surgical site, or some point in between.

As mentioned above, embodiments disclosed herein may be manufactured such that a variety of hybrid cannula 300 options exist with dam 504 positioned in various locations within passage 508 of second portion 500. In some embodiments, hybrid cannula 300 may be cut or otherwise modified in the operating room for a desired surgery.

Advancement of hybrid cannula 300 into a patient may involve translation or rotation or some combination thereof. For example, hybrid cannula 300 may be pushed or threaded into soft tissue. In some embodiments, an arthroscope or other visualization tool may be advanced into the patient to see how far hybrid cannula 300 needs to be advanced. In some embodiments, markings on hybrid cannula 300 may enable advancement of hybrid cannula 300 to a desired depth. Example markings may include, but are not limited to, tool markings, laser lines, threads on the exterior of first portion 400 of hybrid cannula 300, etc. In one embodiment, an arthroscope or other visualization tool may be used to determine whether hybrid cannula 300 has been inserted properly through the soft tissue.

In some embodiments, hybrid cannula 300 may be advanced until the distal end contacts a selected body part, opening, space, or tissue. For example, in some embodiments in which hybrid cannula 300 has a flexible distal end, the tip may be advanced until the tip contacts the desired tissue, which may allow a surgeon to operate without debris approaching the surgical site as the surgeon is operating.

Once advanced to a desired depth, one or more tools may be advanced into the patient via a passage in the hybrid cannula.

Removal of hybrid cannula 300 may include removal of tools from inside passage 508, rotating or pulling hybrid cannula 300 to disengage threads 404 from tissue, and removing hybrid cannula 300 from the patient. One or more sutures may be applied to close the incision.

FIGS. 18*a*-18*b* and FIGS. 19*a*-19*b* depict embodiments of hybrid cannula 300 which may be manufactured using multiple overmolding passes or manufactured to have selected features. As depicted in FIGS. 18*a* and 18*b*, first portion 400 may be formed in a first process and second portion 500 may be overmolded or otherwise formed in a second process to form internal features such as dam 504 as well as external features such as thread 1804. As depicted in FIGS. 19*a* and 19*b*, more than one overmolding process may be used to manufacture features onto hybrid cannula 300. For example, first portion 400 may be formed in a first process. A first overmolding process may be used to form dam 504 and other internal features of second portion 500, and a second overmolding process may be used to manufacture thread or ribbing 600. Other features or molding processes may be useful.

FIGS. 20*a*-20*e* depict embodiments of cannula 300 manufactured using multiple molding processes. For example, manufacturing cannula 300 may include forming flange 402 and overmolding a first flexible material to form thin membrane 502, forming body 710 and overmolding a second flexible material to form dam 504, and joining flange 402 with body 710 to form hybrid cannula 300 such that passage 508 is formed with thin membrane 502 and dam 504 therein. Flange 402 and body 710 may be assembled and fixed together using a number of methods including, but not limited to, for example, adhesives, sonic welding, and/or mechanical fixation. Because hybrid cannula 300 depicted in FIGS. 20*a*-20*e* is manufactured in parts, opening 507 and/or slits 506 are not needed (see FIG. 9*b*). Since a core pin does not pass through thin membrane 502 during molding of second portion 500, opening 507 and/or slits 506 are not necessary. Thus, thin membrane 502 may undergo a secondary slitting operation to manufacture slits 596 without opening 507 for example.

The detailed description and the specific examples described above, while indicating the preferred embodiments, are given by way of illustration only and not by way of limitation. Descriptions of known materials and manufacturing techniques may be omitted so as not to unnecessarily obscure the disclosure in detail. Various substitutions, modifications, additions and/or rearrangements within the spirit and/or scope of the underlying inventive concept will become apparent to those skilled in the art from this disclosure.

As used herein, the terms "comprises," "comprising," "includes," "including," "has," "having," or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a process, product, article, or apparatus that comprises a list of elements is not necessarily limited only those elements but may include other elements not expressly listed or inherent to such process, process, article, or apparatus.

Furthermore, the term "or" as used herein is generally intended to mean "and/or" unless otherwise indicated. For example, a condition A or B is satisfied by any one of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present). As used herein, including the accompanying appendices, a term preceded by "a" or "an" (and "the" when antecedent basis is "a" or "an") includes both singular and plural of such term, unless clearly indicated otherwise (i.e., that the reference "a" or "an" clearly indicates only the singular or only the plural). Also, as used in the description herein and in the accompanying appendices, the meaning of "in" includes "in" and "on" unless the context clearly dictates otherwise.

It will also be appreciated that one or more of the elements depicted in the drawings/figures can also be implemented in a more separated or integrated manner, or even removed or rendered as inoperable in certain cases, as is useful in accordance with a particular application. Additionally, any signal arrows in the drawings/Figures should be considered only as exemplary, and not limiting, unless otherwise specifically noted.

It should be understood that the inventive concepts disclosed herein are capable of many other modifications. To the extent such modifications fall within the scope of the appended claims and their equivalents, they are intended to be covered by this patent. It should also be understood that the term "a" as used herein generally means "one or more" and is not intended to be construed in a singular sense. In addition, the operations described in connection with the methods of the disclosure need not necessarily be executed in the sequence described, as they may be executed in a different sequence consistent with the principles of the disclosure.

What is claimed is:

1. A cannula consisting of a first part affixed to a second part, wherein the first part comprises:
- a first flange formed from a first material having a first rigidity, the first flange comprising:
  - a proximal end;
  - a distal end;
  - a first passage extending between the proximal end and the distal end of the first flange; and
  - a membrane overmolded and permanently fixed to the first flange at the distal end of the first flange, the membrane formed from a second material having a first flexibility;

wherein the second part comprises:
- a body formed from a third material having a second rigidity, the body comprising:
  - a proximal end;
  - a distal end;
  - a second passage overmolded and permanently fixed to the body and extending between the proximal end and the distal end of the body, the second passage formed from a fourth material having a second flexibility; and
- a first dam formed from the fourth material and extending from within the overmolded second passage between the proximal end and the distal end of the second part,
- wherein the first passage of the first flange and the second passage of the body form a single passage along a length of the cannula.

2. The cannula of claim **1**, wherein the membrane is overmolded to the first flange before the first flange and the body are coupled.

3. The cannula of claim **1**, wherein the fourth material is overmolded to the body before the first flange and the body are coupled.

4. The cannula of claim **1**, wherein the body is coupled to the first flange before the fourth material is overmolded to the body.

5. The cannula of claim **1**, wherein the fourth material is formed to further comprise one or more of a second flange or a length that extends beyond a distal end of the body.

6. The cannula of claim **1**, further comprising a thread or ribbing on an outer surface of the body.

7. The cannula of claim **1**, wherein the membrane comprises one or more slits.

8. The cannula of claim **1**, wherein the first material and the third material are the same material.

9. The cannula of claim **1**, wherein the second material and the fourth material are the same material.

10. The cannula of claim **1**, wherein:
- the first material comprises at least one of polycarbonate, polyetheretherketone, or acrylonitrile butadiene styrene;
- the third material comprises at least one of polycarbonate, polyetheretherketone, or acrylonitrile butadiene styrene;
- the second material comprises at least one of silicone, thermoplastic elastomer, polyurethane, or rubber; and
- the fourth materials comprises at least one of silicone, thermoplastic elastomer, polyurethane, or rubber.

11. The cannula of claim **1**, further comprising a surface feature on at least a portion of an outer surface of the first flange for insertion and engagement with a tool.

12. The cannula of claim **1**, wherein the fourth material extends from the distal end of the second part, forming an overmolded extension that covers at least a portion of an outer surface of the body.

13. The cannula of claim **12**, wherein the overmolded extension terminates with a protrusion at the distal end of the second part.

14. The cannula of claim **1**, wherein the first dam further comprises one or more radially disposed openings.

15. The cannula of claim **14**, wherein the one or more radially disposed openings comprise slits.

16. The cannula of claim **15**, wherein the membrane comprises one or more slits.

17. The cannula of claim **16**, wherein one or more first dam slits and one or more membrane slits are aligned about a central or longitudinal axis along the length of the cannula.

18. The cannula of claim **17**, wherein the one or more first dam slits and the one or more membrane slits are rotationally offset with respect to each other.

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